RESEARCH PROTOCOL FOR THE DIGITALIZATION OF AGRICULTURE IN THE NORTHERN BARAGAN PLAIN, ROMANIA

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Abstract. *The paper presents the plan for a research project, entitled Research on the digitalization of agriculture in Northern Baragan Plain, through the use of drones and satellites, with the purpose of monitoring crops and efficiency [AGRODATA]. This knowledge supplied by the modern solutions currently appropriate can be valued and transferred to interested farmers by creating an online database (web-portal) to be accessed by farmers who want crop monitoring with the help of satellites and remote piloted drones. With the help of the AGRODATA database, farmers who will join the project and will register with us from the second year of project implementation, after validating the results of the first year, will have access to updated data on the health of the monitored crops, including various warnings and recommendations formulated by scientific researchers.The steps for creating the soil sensor network, the online database, the soil and crop scanning with the help of drones and satellites, with the formulation of warnings and recommendations for each soil are presented. Starting from the climatic data, continuously recorded, to the realization of the agrochemical maps and to the monitoring of the crops, the working method and the advantages of using the Agrodata system are presented in stages. The increase in economic efficiency through the use of this system derives from the fact that the attack of diseases and pests is observed in time, phytosanitary treatments can be carried out locally, so that the consumption of diesel and pesticides decreases significantly. By using the Agrodata system, it is estimated an increase in the economic efficiency of field and horticultural crops from 20 to 35%.*

Key words*: remote sensors, drones, satellites, agriculture, digitalization*

INTRODUCTION

The research proposed in this project is endorsed by the need for farmers to reduce trekking across their land, under the conditions of obtaining updated real-time information on crop status. This knowledge supplied by the modern solutions currently appropriate can be valued and transferred to interested farmers by creating an online database (web-portal) to be accessed by farmers who want crop monitoring with the help of satellites and remote piloted drones. With the help of the AGRODATA database, farmers who will join the project and will register with us from the second year of project implementation, after validating the results of the first year, will have access to updated data on the health of the monitored crops, including various warnings and recommendations formulated by scientific researchers. AGRODATA is an innovative project for the North Bărăgan area, which proposes a digitized working system for farmers, using drones and satellites, so that the agricultural crops can be monitored during all the vegetation period, and the respectively acquired data will be available online in any moment to those farmers who will join later AGRODATA platform. Monitoring will be carried out systematically, for each culture, from its start, as follows: a) by scanning the soil with a specific scanner or apps for making differentiated recommendations on soil works, b) weather satellite station (for monitoring pedo-climatic indices), c) then in each phenophasis until harvesting, trough repeated flight using drones equipped with NIR cameras, for the production of

orthophotoplans (geo-referenced maps and NDVI maps) by P1-UDJ Galati, and d) with field observations, biometries, laboratory analyses and interpretation of results by the laboratory of agrochemical analyses of P2-SCDA Braila.
The research proposed in this project is supported the need for farmers to reduce field trips, in order to obtain some real-time updated information on crop status.
This knowledge provided by modern solutions currently applicable can be capitalized on and passed on interested farmers by creating an online database to be accessed by farmers who wish remote crop monitoring using drones and satellites. Through this database we we propose to create it through the AGRODATA project, farmers who will register from the second year of implementation of the project, after validation of the results of the first year, will have access to updated data on the situation of field crops, as well as will receive the necessary recommendations for obtaining productions of quality.

MATERIAL AND METHODS

By organizing working meetings and field trips belonging to the coordinator - SC Livandi SRL and partner 2 - SCDA Brăila, the soils of interest for the implementation of the project in the agricultural year 2020 - 2021 were identified, then the maps were made, with the help of satellite representation (Fig. 1 a and b).

a) b)

Fig. 1. Spatial distribution of the experimental perimeters chosen for the implementation of the AGRODATA project at CO - SC Livandi SRL (a) and at P2 - SCDA Brăila (b)

For the pedoclimatic characterization of the experimental perimeters, the following complex determinations were made:

- Registration and presentation of climate data of the previous agricultural year within SCDA Brăila, as a starting point,
- Realization of the experimental protocol for soil sampling and agrochemical analysis,
- Taking average soil samples from the experimental perimeters of SC Livandi SRL and interpreting the data using MATLAB software.

For the agrochemical mapping of the land within the experimental perimeters, the working method was established which required the completion of three phases, namely:
- ***Field phase*** - consisted in taking a number of 648 individual samples on the depth of 0 - 25 cm, by the diagonal method, using the agrochemical probe, from Vădeni area, Brăila county, from a total area of 564 ha, respectively from 53 homogeneous plots, forming in the end 53 average soil samples.
- ***Laboratory phase*** - in which the average samples were conditioned and ground, after which the following analyzes were carried out:
o reaction of the soil (pH) in aqueous suspension soil: water ratio of 1: 2.5, determined potentiometrically, using the pH meter HI 9811-5, SR7184-4 2001.
o the total content of soluble salts, in aqueous extract soil: water ratio of 1: 5, in mg / l, was determined conductometrically, using the conductometer HI 993310, STAS 7184 / 7-87

o content of ammoniacal nitrogen and nitric nitrogen, in mg / l (N-NH4 - Nessler standard method, STAS 10812-76 and N-NO3 - Standard cadmium reduction method - STAS 10314 - 84) - by photocolorimetry, using photocolorimeter HI 83225. Within the same working method, the ammonium and nitrate contents were determined, by the chemical transformation function of the photocolorimeter;

o the mobile phosphorus content expressed in parts per million (ppm P) was determined by photocolorimetry, with the concomitant determination of phosphates (PO_4) and phosphorus pentoxide (P_2O_5) (in mg / l) - Standard Amino Acid method - STAS 7184 / 14- 79.

o the mobile potassium content expressed in mg / l (K + and in K2O) was determined by photocolorimetry, using the photocolorimeter HI 83225 - Standard turbidimetric method - SR ISO 5317: 1997.

The results of the analyzes were recorded in table 2 “Analysis bulletin”.

- ***Office phase*** - consisted in ordering the sheets with the interpretation of data and laboratory results, analysis of the limiting factors of agricultural production, creation of cartographic materials, interpretive tables and fertilization plans, depending on the crop structure desired by the beneficiary and expected productions . Based on the results of the laboratory analyzes, MATLAB maps and graphs were made by P1 - UDJ, based on which P2 - SCDA Brăila, through the research team, made recommendations regarding the rational and efficient administration of chemical and / or organic fertilizers, for to ensure the obtaining of superior agricultural productions from a quantitative and qualitative point of view, on the whole analyzed area, in conditions of maximum economic efficiency.

RESULTS AND DISCUSSIONS

The analysis of the pluviometric regime of the agricultural year 2019-2020 allows the specification of the following particularities:

• Overall, the agricultural year 2019-2020 (September 2019- August 2020) was characterized as an excessive year of drought, because rainfall (Brăila Meteorological Station) totaled 220 mm, with a deficit of 222 mm compared to the multiannual monthly average of 442mm. The seasonal distribution attests to the following:

• Poor rainfall, totaling 34 mm (95 multi-year) with a deficit of 61 mm
• Winter also poorly supplied, accumulating 46 mm (91 multiannual) and deficit of 45 mm
• Poor spring, with only 53 mm (multi-year 109 mm) with a deficit of 56 mm
• Summer also poor in rainfall, with 88 mm cumulative, with a deficit of 59 mm

The analysis of the thermal regime for the agricultural year 2019-2020 (September 2019- August 2020) attests the following:

- The annual average air temperature, with the value of 13.2°C exceeded the multiannual average of 10.9°C by 2.3°C which characterizes the agricultural year as being very hot.
- In terms of temperature, autumn was warmer than normal in the area on average by 2.4°C, winter by 3.7°C, spring by 1.5°C and summer exceeded the multiannual average by 1.7°C .

The determinations regarding the soil water reserve on the depth of 0 - 125 cm, made in the Agrochemical Studies Laboratory of SCDA Brăila, highlight that at the end of September, the soil water deficits were at the following levels: - 667 mm/m^2 in the crop of maize, - 863 mm/m^2 for sunflower cultivation and - 931mm/m^2 per field, after harvesting autumn crops (Table 1).

Table 1.

The main climatic elements in the period September 1, 2019 - August 31, 2020

Climatic elements		2019				2020								TOTAL AVERAGE
		IX	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	
Precipitation (mm)	Month average	1	23,9	8,7	14,3	4	28	2,6	4,6	45,8	30,1	54,8	3,1	220
	Multiannual month average	32	30	33	36	28	27	26	35	48	62	46	39	442
	Deviation	-31	-6,1	-24,3	-21,7	-24	1	-23,4	-30,4	-2,2	-31,9	8,8	-35,9	-222
	Σ		-61,4			-44,7			-56			-59		
Temperature (°C)	Month average	18,5	13,2	10,2	3,9	0,9	4,6	8,7	11,9	16,4	22	24,4	24,6	13,2
	Multiannual month average	17,3	11,5	5,6	0,6	-2,1	-0,2	4,7	11,2	16,7	20,9	22,9	22,1	10,9
	Deviation	1,2	1,7	4,5	3,3	3	4,8	4,1	0,7	-0,3	1,1	1,5	2,5	2,3
	Average		2,4			3,7			1,5			1,7		

According to this model of analysis of climatic conditions, we will work for the agricultural year 2020 - 2021 and for the following years, in order to correctly interpret the production data in correlation with the recorded climatic data.

The registrations from the agricultural year 2020 - 2021 will be centralized according to the same model and reported in Stage 2/2021, both for CE Chişcani - SCDA Brăila, and for the experimental perimeters within SC Livandi SRL, Vădeni commune, Brăila county.

In order to draw up the 3D maps of the soil reaction, soil samples were taken from the plots highlighted in fig. 2 which were analyzed in the laboratory of SCDA Brăila, according to the potentiometric method, in aqueous soil suspension: water 1: 2.5. The results of the soil reaction (pH) for the collected samples are presented in table 2 and represented graphically, fig. 3.

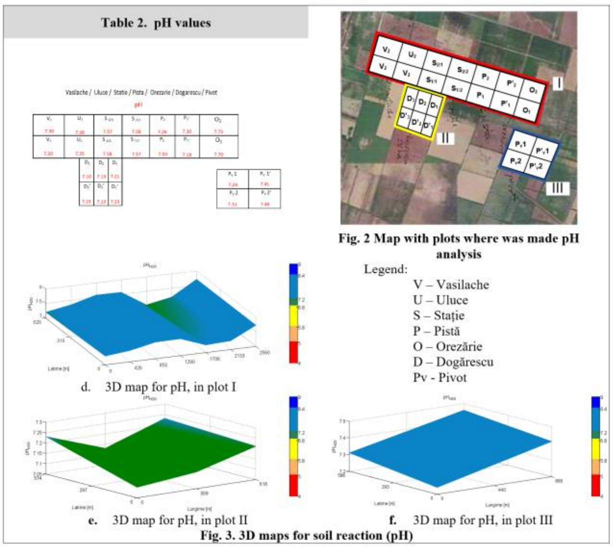


Fig. 2 Map with plots where was made pH analysis

d. 3D map for pH, in plot I

e. 3D map for pH, in plot II

f. 3D map for pH, in plot III

Fig. 3. 3D maps for soil reaction (pH)

Soil samples taken from the agricultural area indicated in fig. 4 were analyzed in the laboratory to determine the nitrogen content, by the standard photocolorimetric method from the aqueous extract soil: water of 1: 5. The values obtained are presented in table 3 and were the basis for raising the 3D maps in fig. 5.

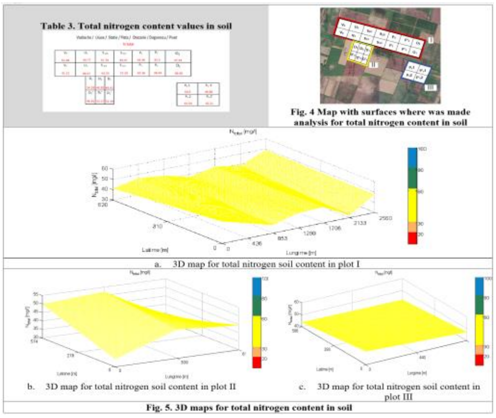


Fig. 4 Map with surfaces where was made analysis for total nitrogen content in soil

a. 3D map for total nitrogen soil content in plot I

b. 3D map for total nitrogen soil content in plot II

c. 3D map for total nitrogen soil content in plot III

Fig. 5. 3D maps for total nitrogen content in soil

Soil samples taken from the land surface indicated in fig. 6, were analyzed in the laboratory to determine the phosphorus content (Table 4). Based on these values, the maps of the phosphorus content for this land were raised, fig. 7.

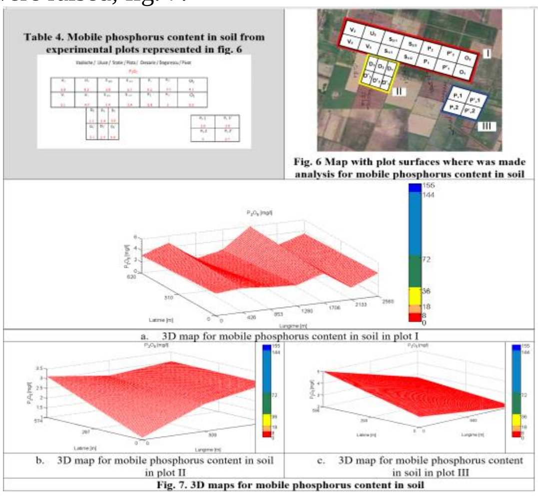


Fig. 6 Map with plot surfaces where was made analysis for mobile phosphorus content in soil

a. 3D map for mobile phosphorus content in soil in plot I

b. 3D map for mobile phosphorus content in soil in plot II

c. 3D map for mobile phosphorus content in soil in plot III

Fig. 7. 3D maps for mobile phosphorus content in soil

Soil samples, taken from the land surface indicated in fig. 8, were analyzed in the laboratory to determine the state of supply of mobile potassium. Based on the values obtained (table 8), the 3D graphs from fig. 9.

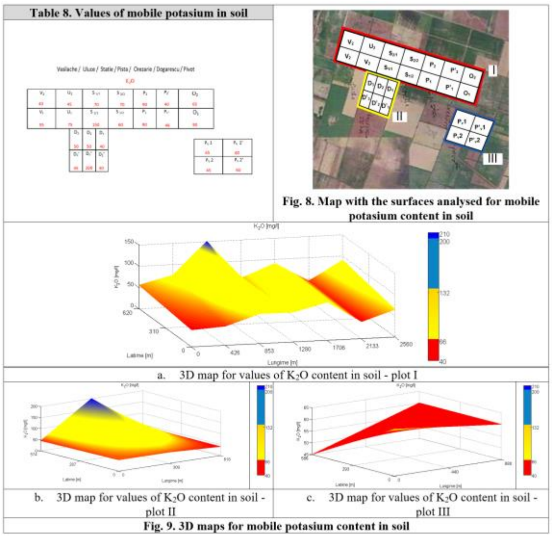


Table 8. Values of mobile potasium in soil

Fig. 8. Map with the surfaces analysed for mobile potasium content in soil

a. 3D map for values of K_2O content in soil - plot I

b. 3D map for values of K_2O content in soil - plot II

c. 3D map for values of K_2O content in soil - plot III

Fig. 9. 3D maps for mobile potasium content in soil

Soil samples, taken from the land indicated in fig. 10, were analysed in the laboratory to determine the state of salt content in soil (table 9), and based on these values, we made the maps from fig. 11.

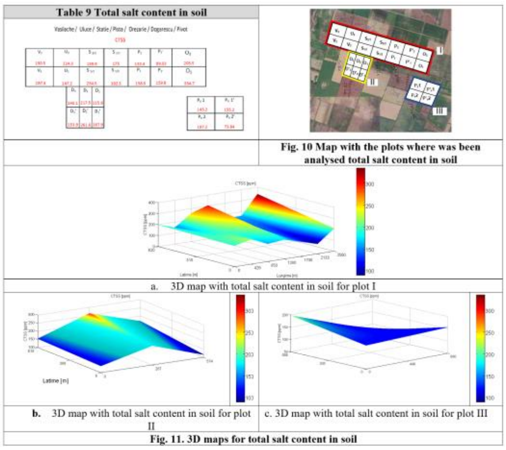


Table 9 Total salt content in soil

Fig. 10 Map with the plots where was been analysed total salt content in soil

a. 3D map with total salt content in soil for plot I

b. 3D map with total salt content in soil for plot II

c. 3D map with total salt content in soil for plot III

Fig. 11. 3D maps for total salt content in soil

In order to ensure normal flight and observation conditions, weather forecasts for the target area were followed. The date 11/19/2020, 10 o'clock, was chosen, the date on which most of the requirements necessary for drone flights and making images in different concatenated spectra were met.

Flight conditions
- Cloud cover <20%
- Temperature 8oC
- Average wind speed 3 m /
- Burst speed 8 - 12 m / s
- Scattered altitude clouds.

Previously, based on the land areas provided by SCDA Brăila within the AGRODATA project, the approximate maps of the respective soils were drawn in Google Maps.
An image resolution of less than 0.1 meters per pixel was considered acceptable.
Considering the EASA norms and the internal norms (drone flight allowed only under a ceiling of 400 feet - 120 meters) a flight height of 70 m was adopted, height maintained automatically (corrections in the range of 0.3 m) by the drone software and sensors .
For the chosen flight altitude and the characteristics of the multispectral objectives, the required resolution is ensured.
Using the specialized software of the data acquisition system, the flight plans were made. For this, the following were taken into account:
- The degree of overlap of the images on the flight direction;
- The degree of overlap of the images on the flight direction was 80%, and on the sides 70%;
- Flight altitude;
- Optical characteristics of multispectral camera lenses;
- Maps of the chosen areas with GPS referencing;
- The flight characteristics of the drone.
Based on these data, the specialized software realizes the flight routes on which the drone will move, indicating the points where the photos will be taken (simultaneously on all cameras). Figures 10 and 11 shows the process of initiating procedures in the field.


Fig. 10. The flight path calculated and represented graphically on the wheat surface.


Fig. 11. Initiation of field procedures

Figure 12 shows the flight path for the abducted surface loaded on the flight control tablet. Although the drone is equipped with an autocorrection system for variations in solar radiation, an initial calibration of the system using a specialized optical system is required (figure 13).


Fig. 12 The flight path, next to the kidnapped field, loaded on the tablet.


Fig. 13. Calibration device (target).

After calibration, the flights were completed. These took place in variable sky conditions. Moments from the unfolding of these flights, recorded on the tablet, are shown in Figure 14 and 15. The points on the routes where the multiple photos were taken are represented.

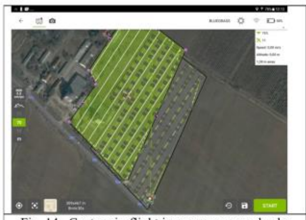


Fig. 14. Capture in-flight image on rapeseed sole.

Fig. 15. Capture in-flight image on wheat soil.

The data obtained, in the form of spectral images, were then processed with specialized software in order to obtain relevant data on the state of crops on the designated lands.

Figure 16 shows, at the beginning of the processing period, the location of the points where the multispectral photographs were taken.

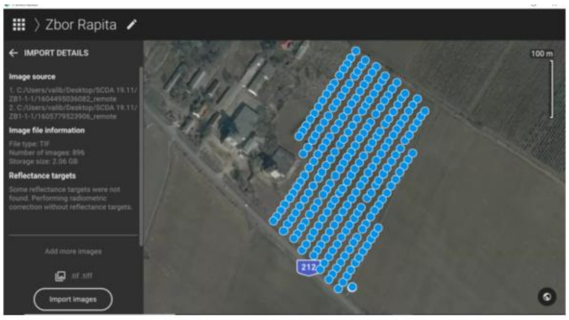


Fig.16. The points from where the multispectral images were taken.

The data, in the form of images, taken from the memory card unloaded from the drone, were entered into the working system of a specialized computer network (figure 17).

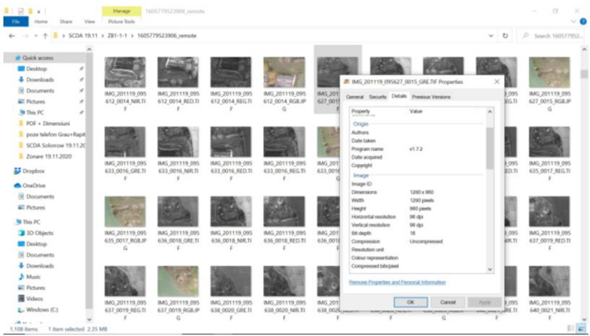


Fig.17. Choice of spectral photos

Based on the flights performed with the help of UAVs, respectively the orthophotoplanets made by the multispectral camera, it was possible to highlight some observations in wheat and rapeseed crops, as reported in figures 18 and 19.

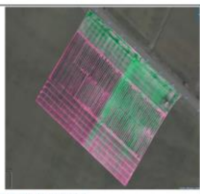
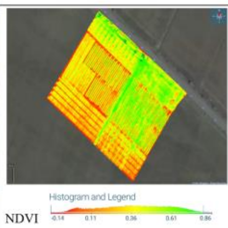
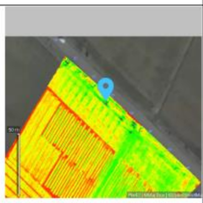
11/19/20 12:26:51 PM GTB Standard Time Duration: 00:05:56 Map center 45.2027287, 27.9198236 (WGS84) Description Zbor 1/1 din 19.11.2020 Area 1.80121719 ha Crop type Grau	 ORTHOMOSAIC	 NDVI
Observations: High density of plants Location: 45.2033377, 27.9199473		

Fig. 18. Making the orthophotoplan and the NDVI map for the autumn wheat crop, followed by field observations to corroborate the information

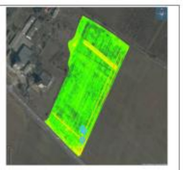
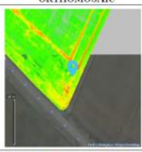
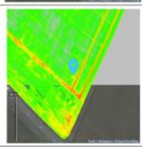
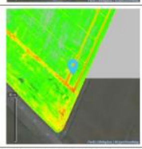
11/19/20 11:55:51 AM GTB Standard Time Duration: 00:08:07 Map center 45.2052166, 27.9206997 (WGS84) Description Zbor 1/1 din 19.11.2020 Area 5.77328674 ha Crop type Rapita Bands 5 (Green, Red, Red edge, NIR, Alpha) GSD 7.24 cm/px		
	ORTHOMOSAIC	NDVI
OBSERVATIONS Differences in plant densities Location: 45.2035874, 27.9205194		
Weeds affected by the herbicide Location: 45.2038977, 27.9205040		
Higher plant density Location: 45.2038296, 27.9205895		

Fig. 19. Making the orthophotoplan and the NDVI map for the autumn rapeseed crop, followed by field observations to corroborate the information

CONCLUSIONS

Based on the results of climatic measurements we can make a prediction about and what technological measures are needed in the near future.

Based on the results of the laboratory analyses, farmer can see on the platform the fertilization plan for each plot, and warnings for real-time disease and pest attacks.

In the second stage of the project, it will be possible to access the treatment recommendations of infection or pest outbreaks, with drone treatment solutions.

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