THE RISK FACTORS MONITORING IN POTATO CROP THROUGH CONTINUOUS SOIL RESOURCES AND VEGETATION STATUS OBSERVATIONS

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Abstract

Increased demands on agricultural production, food security and safety, and environmental quality require improvement of agricultural management. This can be achieved through continuous monitoring and precise production factors (anthropic, biological, edaphic and climatic).

Progress in quality, reliability and diversification of contact and remote sensing sensors for monitoring soil resources and vegetation condition of crops, allow precision management efficiency and environment friendly.

This paper presents results from NIRDPSB Brasov using sensors for:

- monitoring "on the go" of soil resources (physical and chemical quality): Veris 3150 MSP Soil EC-NIR Spectrophotometer, Spectrum SC-900 Soil Compaction Meter, Spectrum TDR-300 Soil Moisture Meter;

- monitoring "on the go" vegetative status (physiological condition and health, water stress and plant nutrition) in crops: CropScan MSR-16R Multispectral Radiometer (400-1500nm), Spectrum CM-1000 NDVI;

- monitoring chemical composition of plants (the amount of chlorophyll and anthocyanin): Spectrum SPAD-502, Opti-Sciences ACM-200 Anthocyanin Content Meter.

All data collected by sensors mentioned are georeferenced (GPS coordinates) and acquired continuously in a Geographic Information System (GIS) to obtain spatial maps of favorability and risk used in performance management of crops.

Key words: potato crop, precision farming, risk factors, sensors

INTRODUCTION

Increased demands on agricultural production, food security and safety, and environmental quality require improvement for the used varieties and for the agricultural management. This can be achieved by knowledge, continuous monitoring and modeling of the production factors (Chiru, Olteanu, 2013).

The progress registered in quality, reliability and diversification of contact and remote sensing sensors for monitoring soil resources and vegetation condition of plants, allow precision management efficiency and environment friendly.

The precision farming has as purpose the improvement of using the ground resources, water and the chemical inputs (fertilizer and pesticide) on specific local bases and has as goals:

- The obtaining high and quality yields, durable in time and space;

• To optimize the economic benefits;
• The entire achivement of environment protection;
• The enlarging of lasting agriculture systems;
• Reducing the price of yields per product.

The precision agriculture asks for a systematically approaching of the biological, ecological and socio–economic elements, and there are distinguished through its space and time elements. The precision agriculture as a result for the necessity of streamlining the quantity of fertilizer and pesticide under the economical, legislative and environment protection presure, benefits rising and control as agriculture systems. Methodological, the precision agriculture sums up all other methos of research (fig.1) of the experimental results, starting from the observation, classical and geographical experiments.(Olteanu et.al., 2002).

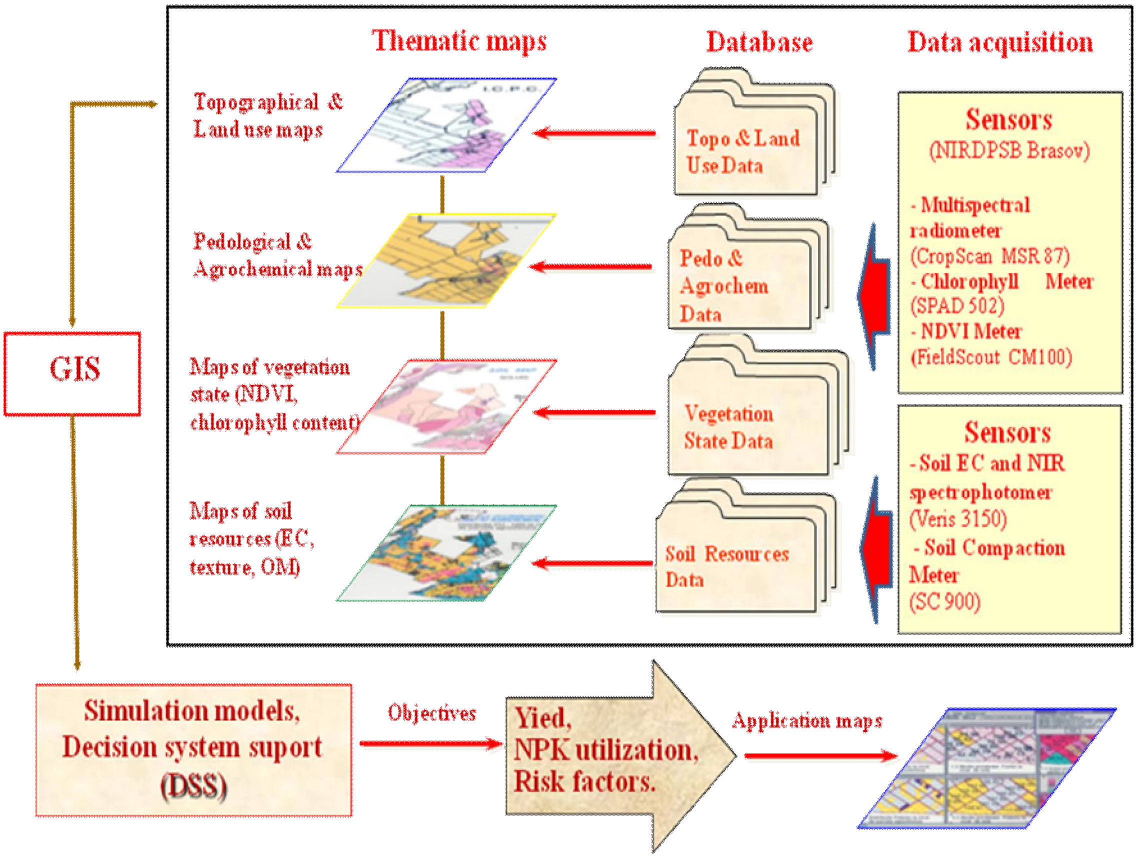

Fig.1 Scheme of using multiple sensors in potato crop "precision farming"

The precision agriculture asks for a systematically approaching of the biological, ecological and socio–economic elements, and there are distinguished through its space and time elements.

Main factors of production are:

A. Biological factors related to: a) the crop with the two components: varieties and the quality plant material; b) competing organisms in the culture medium: weeds, pathogens (viruses, bacteria, fungi) and animal, pests (nematodes, insects, etc.).

B. Growth factors – environment in which plants grow and develop: a) climatic factors (solar radiation, temperature, precipitations); b) soil factors (structure, moisture, soil fertility).

C. Socio-economic and technological factors related to: a) production system (organization form and the motivation that we have for production); b) economic status (material investment opportunities, profitability culture); c) knowledge and application of technology opportunities.

MATERIAL AND METHOD

This paper present the research activity who was performed on the 1150 plot (20 ha), in 1781 points with a depth variation between 0 – 90cm. In each point of determination we used Trimble GeoExplorer in order to georeference the date and to correlate them with the available digital maps.

For monitoring the production factors, we used the following sensors: for soil resources, monitoring "on the go" (physical and chemical quality) Veris 3100 Mobile Sensor Platform, Soil Compaction Meter SC 900 and Soil Moisture Meter TDR 300; and for the crop vegetation status: CropScan MSR-16R Multispectral Radiometer with 16 wavelengths between 400-1500 nm, SPAD 502 Plus and CM-1000 NDVI Meter.

All data collected by sensors mentioned are georeferenced (GPS coordinates) and acquired continuously in a Geographic Information System (GIS) to obtain spatial maps of favorability and risk used in performance management of crops.

RESULTS AND DISSCUSIONS

Results regarding the monitoring of soil resources

The electrical conductivity (also called specific electrical conductivity) is the physical size which characterizes the ability of a material to transmit (conduct) an electrical charge. It is an intrinsic property of the material as well as other properties such as density and porosity. Data on the electrical conductivity of the ground is present as a map showing how some soil types vary in their ability to conduct electricity (Corwin and Lesch, 2005, Olteanu, 2006, Turcu et.al, 2008).

The soil EC principle measurement using the contact sensors involves the use of three pairs of knife electrodes. Each pair of electrodes is used to generate an electric current in the soil, while the other two are used to measure the voltage drop (fig.2). The electrode assembly is mounted on a bar which is pulled by a motor device.

Fig.2 Soil electrical conductivity monitoring with VERIS (Mobile Sensor Platform)

The mean value of EC on deepness of 0-30 cm, which resulted with the measurements from de 02.05.2013, was 17.0 mS/m. The EC amount were situated between minimum 5.4 and maximum 36.2 mS/m. The mean value of EC on deepness of 0-90 cm, was 18.65 mS/m, with minimum of 5.9 and maximum 35.7 mS/m. The variation coefficients obtained 27.23 % and 24.62 % indicates a medium spatial variability of soil electrical conductibility (Puiu et al, 2012, Puiu et al., 2013, Puiu et al, 2014, Puiu 2014) (fig.3).

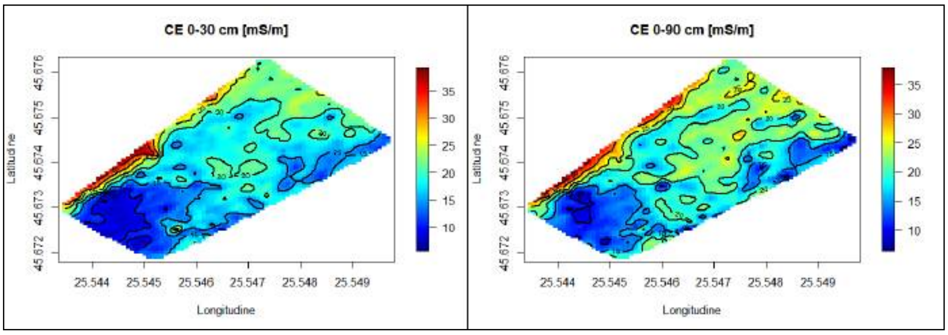

Fig.3 The shallow and deep EC, Stupini area maps

In figure 4 is presented the spatial variability percent of the organic matter and pH value in arable soil. The average organic matter content of the profile, resulted an amount of 5.7 %, with a variation coefficient of 24.4 %, and values between 3.1 şi 7.0 %. The soil fertility caracterization arise from the content of organic matter, therefore results a high soil fertility. A pH map of the soil is very useful for applying the fair and precise amendments where required. The unvaryingly application is a less expensive method compare to the common method, the one of applying on the whole piece of field (Puiu, 2014).

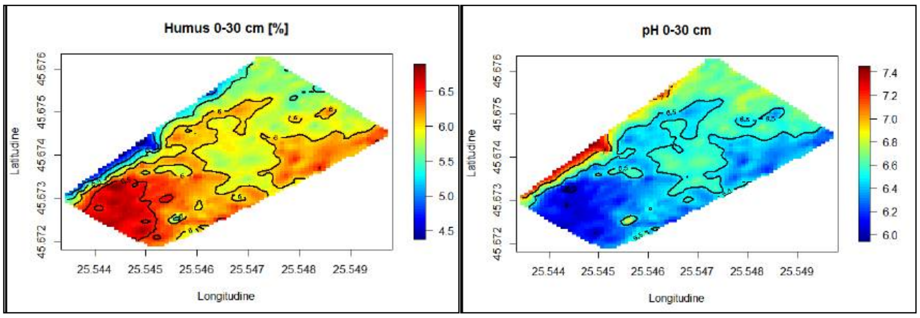

Fig.4 The humus and pH map

Following the analysis of the potato seed of the observation point through the study arise that the average seed of tubers yield was considerable high at Desireé variety regarding to the Christian variety, therefore 37,6 t/ha and 33,6 t/ha (fig. 5,6) An important aspect was the high number of tubers of a nest, as well as the weight of the tubers giving insignificant result for the statistical point of view.

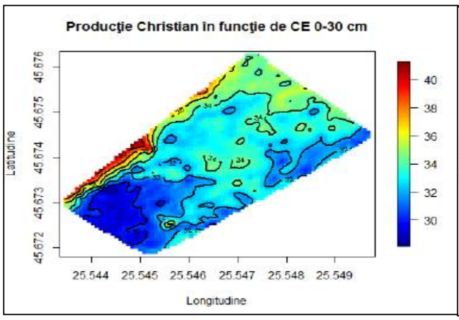

Fig.5 The spatial variability yield potato map, Christian variety (t/ha)

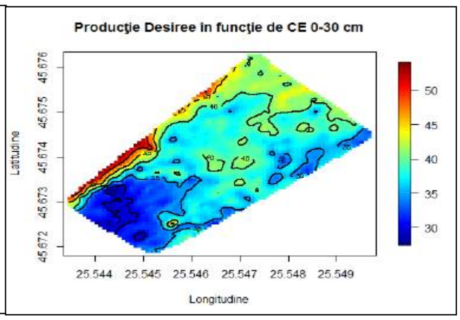

Fig.6 The The spatial variability yield potato map, Desiree variety (t/ha)

The spatial variability of the tubers number and the nest production as well at hectare in the examining points is given through the variation coefficients which indicates average to high variation at Christian variety (VC between 20,2 and 27,9%) and low to average Desireé variety (VC between 13,1 and 16,0 %).

Results regarding the vegetation status of potato crop

To characterize the vegetation status of potato crop there are a range of specific indicators. For leaves chlorophyll content we used SPAD 502

Plus (fig.7) and NDVI vegetation index we determined with CproScan, multispectral radiometer (fig.8).

Fig.7 Monitoring the leaf chlorophyll content of potato crop with SPAD 502

Fig.8 Monitoring the the reflectance of potato crop with CropScan

In table 1 we can find the average values of leaves chlorophyll content at the Christian and Desiree varieties at three different time of determination in plants coming from minitubers. In Desiree variety plants the medium amount of leaves chlorophyll content was 49.5 SPAD units, higher than that of the Christian variety, which had an average of 47.6 SPAD units only. The highest values were recorded during the first measurements in both cultures, which took place on 19.06.2012, when plants were young, and the foliage less developed.

Table 1

The mean values of leaf chlorophyll content for minitubers culture Christian and Desiree determined during the flowering season

Date	**Crop**						**Mean**		
	Christian			**Desireé**					
	SPAD units	Duncan Test	CV %	SPAD units	Duncan Test	CV %	SPAD units	Duncan Test	CV %
19.06.2013	49,4	B	8,0	53,3	A	4,7	51,3	A	7,4
03.07.2013	46,5	C	7,0	47,7	C	5,8	47,1	B	6,4
22.07.2013	47,0	C	13,5	47,4	C	8,8	47,2	B	11,2
Mean	47,6			49,5 *			48,6		
CV %	10,0			8,4			9,4		

DL 5% (soi) = 1.0 SPAD units
LSD 5% (data) = 1.0 SPAD units
LSD 5% (soi * data) = 1.4 SPAD units

As a result of the comparison between varieties and biological categories of NDVI vegetation index during the period of vegetation were found significant differences at our next June. On June 6th at the three cultures Christian Prebase, Christian Superelite and Desiree Elite were recorded significantly different values presented in table 2, which are in line with the development of canopy, as well as the degree of ground coverage with vegetation. At this time the variation coefficients of NDVI values were the most lift, beating 33%.

Table 2

The mean values of leaf NDVI vegetation index for minitubers culture Christian and Desiree determined during the flowering season

Date	Crop						Mean		
	Christian			Desireé					
	NDVI	Duncan Test	CV %	NDVI	Duncan Test	CV %	NDVI	Duncan Test	CV %
19.06.2013	0.91	A	3.0	0.86	B	2.7	0.88	A	3.8
03.07.2013	0.87	B	4.5	0.86	B	5.9	0.87	A	5.2
22.07.2013	0.81	C	3.9	0.84	BC	3.7	0.82	B	4.0
Mean	0.86*			0.85			0.857		
CV %	5.9			4.4			5.2		

DL 5% (soi) = 0.00 (2.01 * 0.0018)
LSD 5% (data) = 0.02
LSD 5% (soi * data) = 0.03

In mid-June, the differences between the NDVI values at the Christian variety have diminished, becoming insignificant, but with significantly higher NDVI value opposed to those of the Desiree variety, where the foliage development has been slower up to this observation. In July the crops showed no more differences based on the vegetation index.

CONCLUSIONS

Following research and results of the study of potato production according to the spatial variability of resources, the following conclusions were drawn:

1. In all studied cultures, the value of leaf chlorophyll content decreased with increasing foliage, dynamic influenced by the redistribution of nitrogen in the plant, this is closely linked to the thermo-hydric conditions;
2. The dynamics of vegetation index NDVI shows a potato crop for seed vigorous and healthy, which was founded in optimal time;
3. The soil electrical conductibility does not directly influence plant growth, but can be used as an indirect indicator of the percentage of macronutrients available to the plants;
4. The electrical conductibility measurement is a very simple method that provides realtime data on the state of soil fertility to the farmers;
5. The soil electrical conductibility is used in precision agriculture to help sustainable performance management application that aims nonuniform fertilization, exactly where it is necessary to increase production.

Acknowledgments

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REFERENCES

1. Chiru S.C., Olteanu Gh.: Direcţii de cercetare abordate în România şi pe plan mondial la cultura cartofului, In: Cartoful în România, 2013, vol. 22, nr. 1,2, p. 1-4.
2. Corwin, D.L. and Lesch S.M.: Apparent soil electrical conductivity measurements in agriculture, 2005, In: Computers and electronics in agriculture, p. 11-43.
3. Goffart, J.P., Oliver M., Frankinet M.: Potato crop nitrogen status assessment to improve fertilization management and efficiency: past – present – future, 2008, In: Potato Research, p. 355-383.
4. Olteanu, C., Zamfira S.,Olteanu Gh., Olteanu F., 2006, An intelligent system for measuring soil electrical conductivity, In: Annals of DAAAM & Proceedings of the 17th International DAAAM Symposium "Intelligent Manufacturing &Automation: Focus on Mechatronics and Robotics", 8-11 nov, Viena, Austria
5. Olteanu, Gh., Oltean I. M., Oltean I.: Agricultura de precizie – un nou concept în cercetarea şi practica agricolă, In: Priorităţi ale cercetării ştiinţifice în domeniul culturilor de câmp, 2002, Ed. Ceres, Bucureşti, p. 99-110.
6. Puiu I., 2014, Studiul producției de cartof în funcție de diversitatea spațială a resurselor, Teză de doctorat, Bibliotecă USAMV Cluj-Napoca, p.203.
7. Puiu I., Morar G., Olteanu Gh., şi Ianoşi M., 2013, Potato crop monitoring using Veris mobile sensor platform, In: Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Vol 70, No. 1, p.113-117;
8. Puiu I., Olteanu Gh., Morar G., şi Ianoşi M, 2012, Monitoring the vegetation status of potato, In: Agriculture Science and Practice Journal, year XXI, p.39-43;
9. Puiu I., Olteanu Gh.,Mărculescu A., Ghinea A., Damșa F., 2014, Soil resources and agricultural crops vegetation status monitoring by using specific and precision sensors, In: Sensing-Monitoring-Telediagnosis for life sciences, vol. 2, Food and environment, p.88-98;
10. Turcu C., Olteanu C., Zamfira S., Olteanu G., Olteanu F, 2008,17th Triennial Conference of the EAPR, Universitatea Transilvania Brașov, p.515-518.