Chapter 7

SOIL RESOURCES AND AGRICULTURAL CROPS VEGETATION STATUS MONITORING BY USING SPECIFIC AND PRECISION SENSORS

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1. Introduction

Increased demands on agricultural production, food security and safety, and environmental quality require improvement both varieties used and the agricultural management. This can be achieved by knowledge, continuous monitoring and modeling of the 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 plants and crop, allow precision management efficiency and environment friendly. Allow both phenotype selection of the new varieties adapted to changing conditions (precision breeding) and improvement of the crop production management (precision farming).

1.1. Precision breeding (phenotyping)

The improvement phenotype referred to as the "Precision breeding" is the determination of morpho-physiological-related gene expression (the phenotype) the specific environmental conditions, based on the availability of digital equipment, modern able to accurately monitor in real time, the plant response adverse environmental conditions. In this way can be selected genotypes with desirable properties such as an example drought tolerance (rate of photosynthesis and transpiration reasonable cell osmotic pressure and stomatal conductance high growth rate and ultimately increased plant production under conditions acceptable thermo-hydric stress). Through methods of "capturing" the traits pursued in the process of breeding, new genotypes with tolerance/resistance to drought can be obtained, with dynamics controlled of biomass, differentiated architecture and higher ratio of water use (WUE), nutrients (NUE) and solar radiation (RUE) [1-3].

Highlighting physiological characteristics related to drought tolerance phenotype potato with work methodologies and equipment used to NIRDPSB Brasov is shown schematically below (Figure 1).

1.2. Precision farming

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 [4] 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.

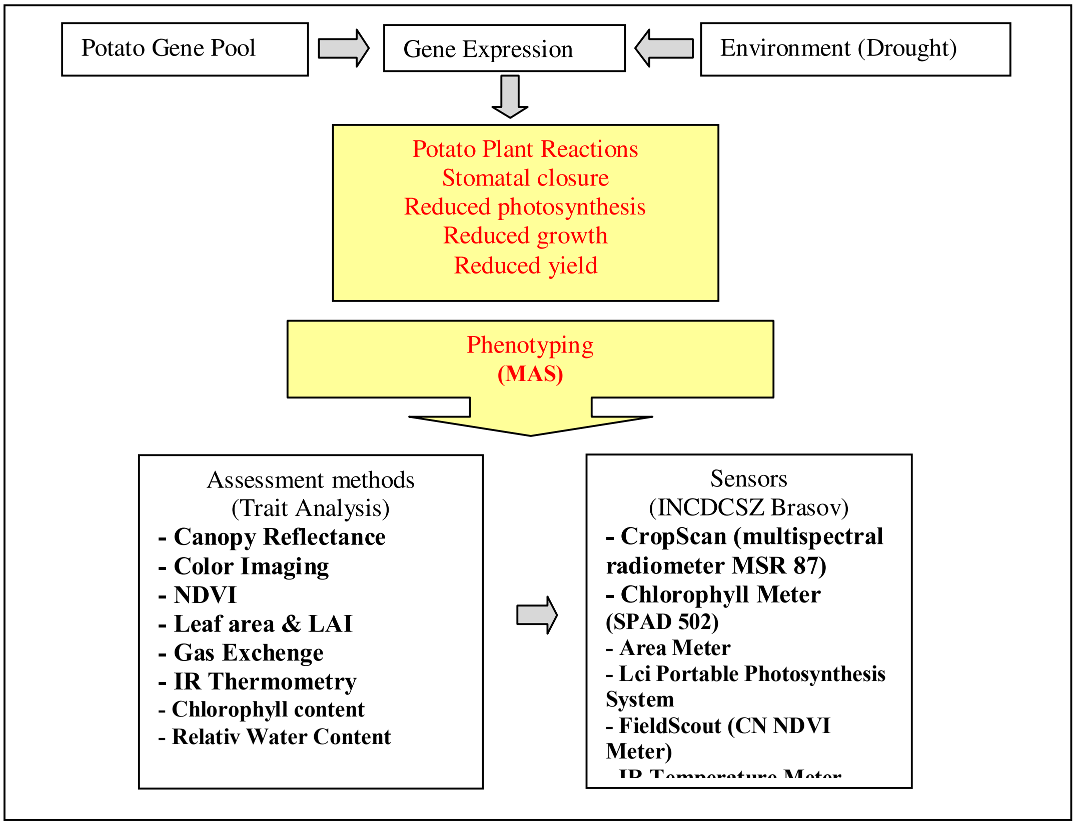

Fig. 1. *The possibility to use phenotyping in potato "precision breeding"*

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 and rendition of the experimental results, starting from the observation, experiencing, classic and geographical, sistematicall aproach, the simulation of the process till the use of upscale geographical technology [4] (Figure 2).

1.3. Production factors and sensors

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).

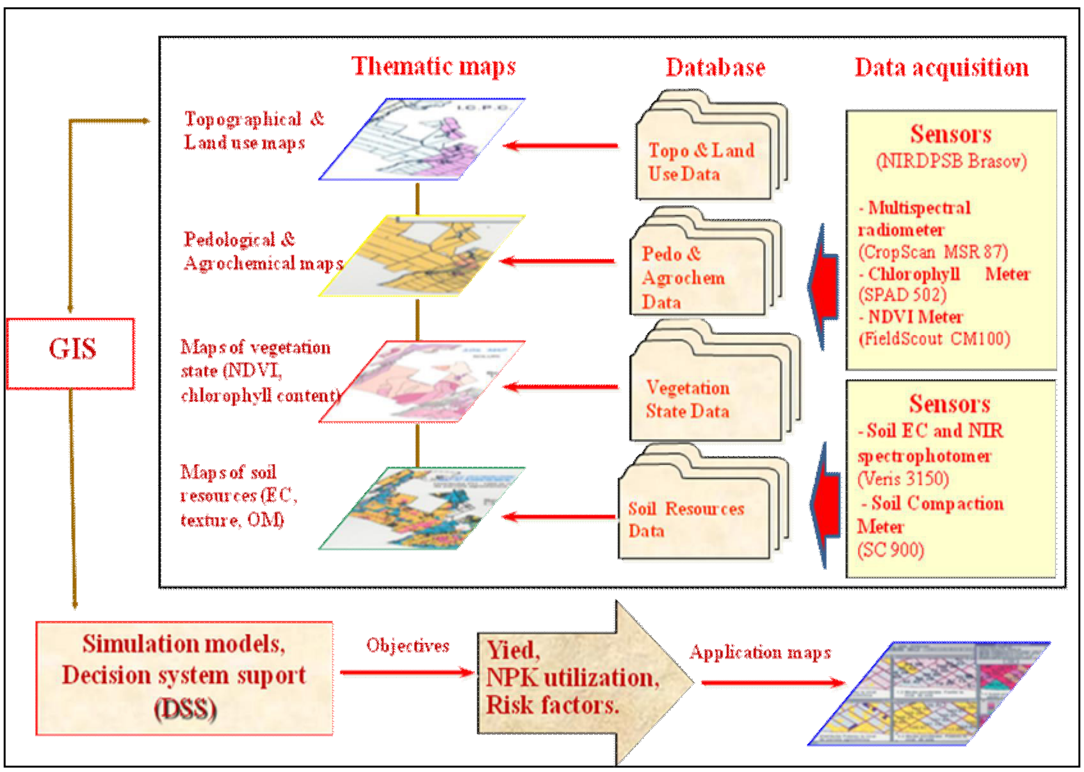

Fig. 2. *Scheme of using multiple sensors in potato crop "precision farming"*

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.

Fig. 3. *Veris 3150 MSP Soil EC-NIR Spectrophotometer*

Fig. 4. *SC 900 Soil Compaction Meter*

Sensors used at NIRDPSB for monitoring of the production factors:

- monitoring "on the go" of soil resources (physical and chemical quality): Veris 3100 MSP Soil EC-NIR Spectrophotometer (Figure 3), Spectrum SC-900 Soil Compaction Meter (Figure 4), Spectrum TDR-300 Soil Moisture Meter (Figure 5), Hand-held pH Meter (Figure 6).

Fig. 5. *TDR 300 Soil Moisture Meter*

Fig. 6. *Hand-held pH 110 Meter*

- monitoring "on the go" vegetative status (physiological condition and health, water stress and plant nutrition) in crops: CropScan MSR-16R Multispectral Radiometer (400-1500 nm) (Figure 7), Spectrum CM-1000 NDVI (Figure 8).

Fig. 7. *CropScan Multispectral Radiometers*

Fig. 8. *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.

2. Results

The paper exemplifies the possibilities of using sensors for monitoring of soil resources and vegetation state of potato crop.

Fig. 9. *SPAD 502DL Plus Chlorophyll Meter*

Fig. 10. *ACM-200 Anthocyanin Content Meter*

2.1. Results on 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 [5, 6].

At NIRDPSB Brasov for continuous measurement of soil electrical conductivity was used a device with six electrodes (Figura 11).

Fig. 11. *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 where the third reserch was held [7]) (Figure 12).

EC values are correlate with the parameter values of soil (humus and pH, Figure 13 and Figure 14) and finally with the production of followed potato varieties Christian (Figure 15) and Desiree (Figure 16).

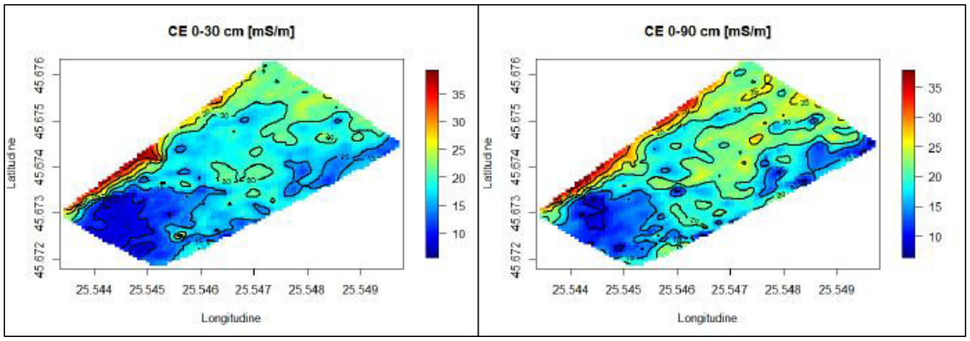

Fig. 12. *The shallow and deep EC, Stupini area maps*

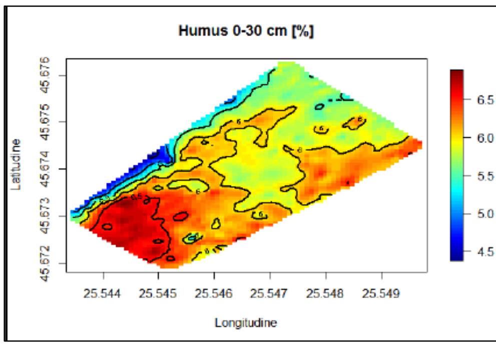

Fig. 13. *Humus map*

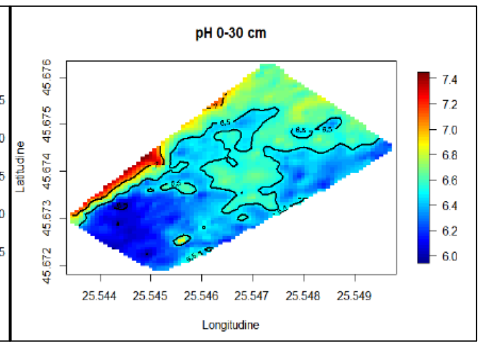

Fig. 14. *pH map*

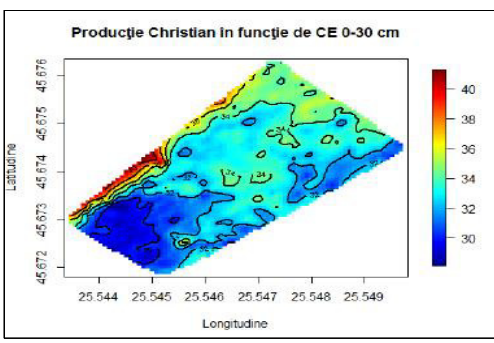

Fig. 15. *The variability yield potato map Christian variety (t/ha)*

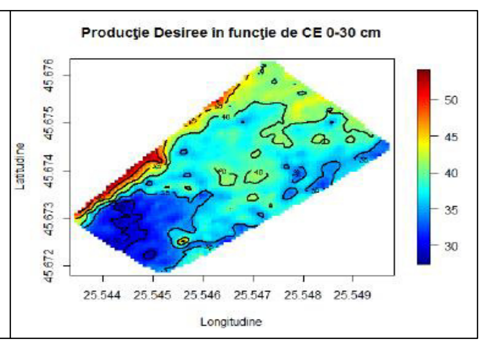

Fig. 16. *The variability yield potato map Desiree variety (t/ha)*

2.2. Results on the monitoring of vegetation state of potato crop

There are a range of specific indicators to characterize the vegetation state of potato crop. In this paper we will exemplify through amount of chlorophyll [8] determined with the equipment SPAD 502 (Chlorophyll Meter, Figure 17) and

NDVI vegetation index determined with the equipment CropScan (MSR-16R, Figure 18).

Fig. 17. *Monitoring the leaf chlorophyll content of potato crop with SPAD 502*

In Table 1 we can find the average values of chlorophyll content in leaves from the Christian and Desiree varieties at three moments of determination in plants coming from minitubers. In Desiree variety plants the medium amount of chlorophyll in the leaves 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.

The leaf chlorophyll content comparing between varieties and biological categories at different time of determination

Table 1

Varieties	06.06.2011		17.06.2011		13.07.2011		28.07.2011	
	Mean	Duncan Test	Mean	Duncan Test	Mean	Duncan Test	Mean	Duncan Test
Christian PB	56.03	A	52.36	A	50.76	A	47.76	A
Christian SE	57.59	A	52.45	A	47.82	B	46.08	A
Desiree E	55.58	A	51.48	A	47.54	B	48.56	A
CV%	9.04		6.27		8.74		9.37	

The highest level of the average amount of chlorophyll in the leaf was recorded at Desiree variety worth 53.3 SPAD units as opposed to the Christian culture who had an average of only 49.4 SPAD units.

Fig. 18. *Monitoring the reflectance of potato crop with CROPSCAN multispectral radiometer*

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 canopie, 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%.

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.

The NDVI vegetation index comparing between varieties and biological categories at different time of determination

Table 2

Varieties	06.06.2011		17.06.2011		13.07.2011		28.07.2011	
	Mean	Duncan Test	Mean	Duncan Test	Mean	Duncan Test	Mean	Duncan Test
Christian PB	0.56	A	0.84	A	0.90	A	0.85	A
Christian SE	0.45	B	0.82	A	0.90	A	0.86	A
Desiree E	0.26	C	0.65	B	0.88	B	0.87	A
CV%	33.33		14.47		1.12		4.65	

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