

## 4

# Intelligent Tools for Environment Monitoring: Features and Applications

### 4.1 Introduction

Remote sensing for agricultural purposes has intensive development in Bulgaria and Ukraine during the last twenty years. The researches in this area are supported by Governments of both countries. Scientists and specialists from the Bulgarian Academy of Sciences, the Agricultural Academy of Bulgaria, National Academy of Sciences of Ukraine, and National Academy of Agricultural Sciences of Ukraine participate in this investigations.

The data of remote sensing can be used in the management only when they are combined with data from synchronous or quasi-synchronous land surface agrophysical and microclimatic measurements and purposeful soil investigations. Bulgarian and Ukrainian teams have accumulated rich experience in this collaborative research on the last years.

Development of agricultural investigations requires quantitative evaluation of the state of main energy budget elements of the soil-plant-surface air layer system on the field for successful management of soil fertility and soil pollution protection. Many of the processes are essential to soil and to nutrition movement and plant growth, such as exchange of heat, moisture and movement of contaminants depended significantly on the soil properties and canopy foliage [Nielsen et al, 1983], [Perry et al, 1988].

Application of electronic devices in field measurements has to be organized with the extreme care, because of their high cost and unique character. Emphasis is placed on the author's task, namely to carry out a characteristic evaluation of the "soil – plant – surface air layer" system's parameters are capable of being subject to electronic measurements, as well as, to propose structures for measurement systems. The measurements have to carry out in the representative places on the field.

The team of the N. Poushkarov Institute organized mobile laboratories for field measurements, included portable devices for soilmoisture and temperature, pH and soil salinity, main elements of the microclimate on the field and microcomputer agrometeorological stations. The purposeful electronic measurements enable to create a database of the heat, water, and mechanical properties of the main Bulgarian soils and to well-ground the main agroecological regions of Bulgaria.

Scientists from V.M. Glushkov Institute of Cybernetics of NAS of Ukraine developed family of portable devices "Floratest" and proper methods for express-diagnostics of plant state. The devices serve as tool for surface validating remote satellite data about vegetation.

There is a common methodology in the European countries for stratification of agricultural lands and by choice of test segments for land surface investigations complementing one another remote sensing estimation and forecasting of the crops growing.

The purpose of the chapter is to show Bulgarian and Ukrainian experience in development of measurement devices and an organization of express and continuous field electronic measurements for evaluation of main water and heat balance elements and plant state on the field.

## 4.2 Measurement methods and structures

Only properties of the water and heat balance elements of the soil-plant-surface-air layer system that can be transformed into corresponding electric signals are included in electronic measurements. They are underground water level; soil moisture, temperature and salinity; water potential of soils and plants; air humidity and temperature; wind velocity and direction; rainfall; solar net radiation; transpiration and evapotranspiration from the field etc.

The authors consider their main task to propose of applicable methods of approach to optimum organization and control of the field electronic measurements, both express and continuous, by using special-purpose sensors, algorithms, and structures of measuring devices and systems. There is an example of combined multi-channel measurement device for soil and leaf temperature and humidity (Figure 59).

The method of sorption sensors in the form of electrical resistance gypsum blocks is used widely based on the relationship between the electric resistance and the equilibrium moisture or matric water potential of the gypsum blocks at the particular soil suction. As a result of studies carried out in the course of several years sorption sensors for moisture of heavy Bulgarian soils are constructed and produced by Agrophysics Department of the Institute of Soil Science 'N. Poushkarov'. The soil moisture meter covers a range of 50 to 100% field capacity with 1.5% accuracy.

It is known that tensiometers have a comparatively simple construction and consist of a porous ceramic cup, connected with a manometer by means of a tube. The team established the production of ceramic cups with the highest possible water conductivity and a pore diameter of maximum about 2 micrometers. The tensiometers can measure a suction of 0 to 800 mbar. The range reflects the energy state of about 50% of available water in most Bulgarian arable lands [Kolev et al, 1986].

Our experience in soil moisture measurements includes laboratory and field evaluation of soil moisture and electrical impedance based on application of TDR meter. The principle of operation of the TDR technique, as applied to dielectric constant measurements is based on the relationship between the velocity of electromagnetic wave propagation and dielectric constant of the medium the wave propagate in [Malicki and Skierucha, 1989]. For continuous measurements on the field we use type of device with 1,5 m plastic tubes.

The instrumental evaluation of soil profile water content allows rapid determination of the irrigation rate of parcels of the agricultural field. More than 20 years working team is developing methods and devices for irrigation management based on soil moisture and temperature evaluation.

The soil properties have different values in different zones of the agricultural field. No effective method for evaluating one or other property distribution is established, but there is an opportunity to use a pattern for an ordered set of closed isolines. In other words, it is possible to consider the unhomogeneous field as numerical homogeneous zones displaying these with tree-root structure, a concept first suggested by [Uchitomi and Mine, 1988].



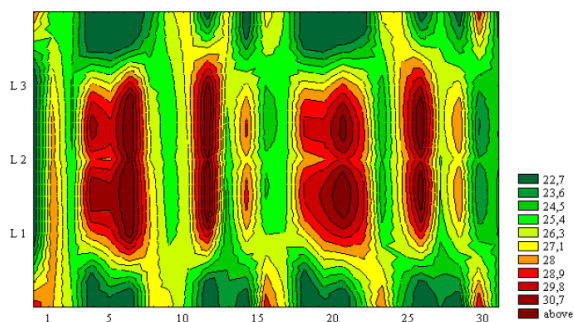
**Figure 59. Multichannel device for field measurements**



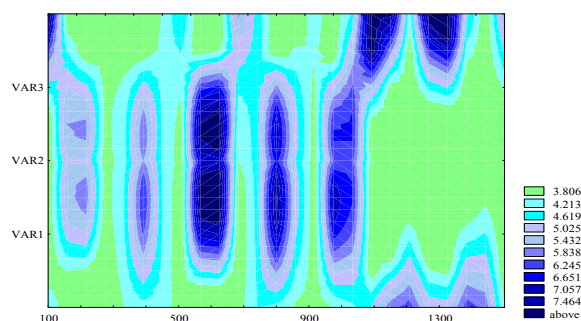
**Figure 60. An IR thermometer for field measurements**

A sensor consisting of two-metal electrode system joined with temperature sensible microdiode, all in a ceramic body, has been designed to monitor the soil profile salinity and temperature in the field. An alternating current digital bridge was used with sensors of soil moisture, temperature, salinity, and frost, every type with own calibration (Figure 59). Temperature measurements of the soil surface and canopy were obtained by infrared thermometer (Figure 60). A portable conductometer and pH-meter was used for evaluation of electrical conductivity and pH of the soil solution in the field conditions.

There are examples of canopy and soil surface temperature and moisture maps shown in Figure 61 and Figure 62.



**Figure 61. Cotton canopy temperature map on 12:00, based on infrared measurements on the field**



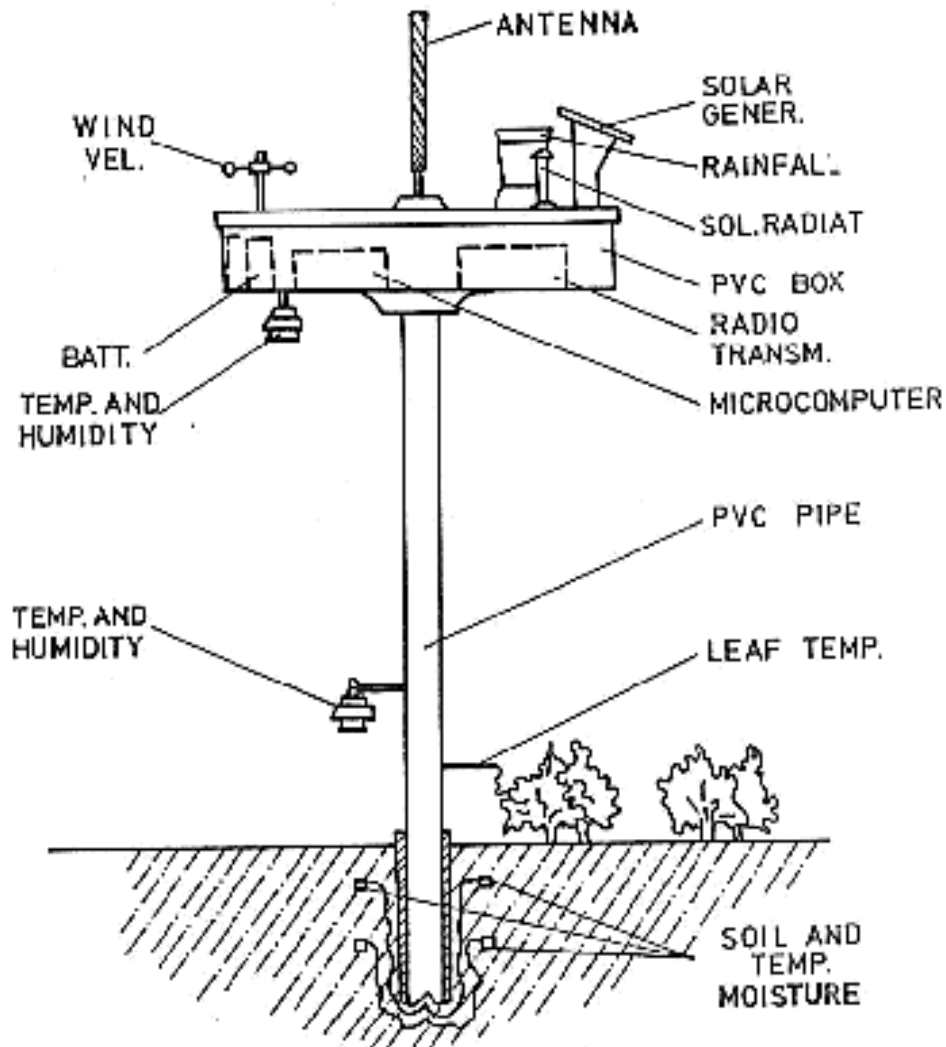
**Figure 62. Soil moisture map of the soil surface of the cotton field**

A portable conductometer and pH-meter was used for evaluation of electrical conductivity and pH of the soil solution in the field conditions.

Agrometeorological parameters, including heat balance elements, have been estimated using several American ARAX systems (Automatic Reporting Agricultural Weather System) [Sampey, 1986]. These types of systems use satellite measurement stations (up to 16) mounted in representative places of crop growing areas. Figure 63 shows an ARAX satellite installation.

The soil moisture and temperature sensors are placed at two depths in the crop root zone. The air temperature and humidity are measured at two levels over the canopy. In addition, a rain gauge,

wind velocity, wind direction, and solar radiation sensors are situated on the satellite top. The satellite can be set up to collect the data at time intervals of 3 min to 4 hours. Frequent measurements need more power and reasonable compromise should be achieved especially in winter. ARAX satellite units transmit the data collected to the base computer station in the High VHF Band (150-174 MHz). In perfectly flat terrain, the maximum range for reception is not more 22 km.



**Figure 63. Structure of a satellite station of ARAX system**

Reports received by the base computer are filed in memory as current weather reports. Regardless of the report period on each hour, the current weather reports from every one of the satellites are averaged or totaled as hour reports. On the same way, 24 hourly and monthly reports are filed. The basic structure of a space distributed in different agrofarms or co-operatives ARAX system is shown in Figure 64.

Registration of main heat balance elements on the field are shown in Figure 65.

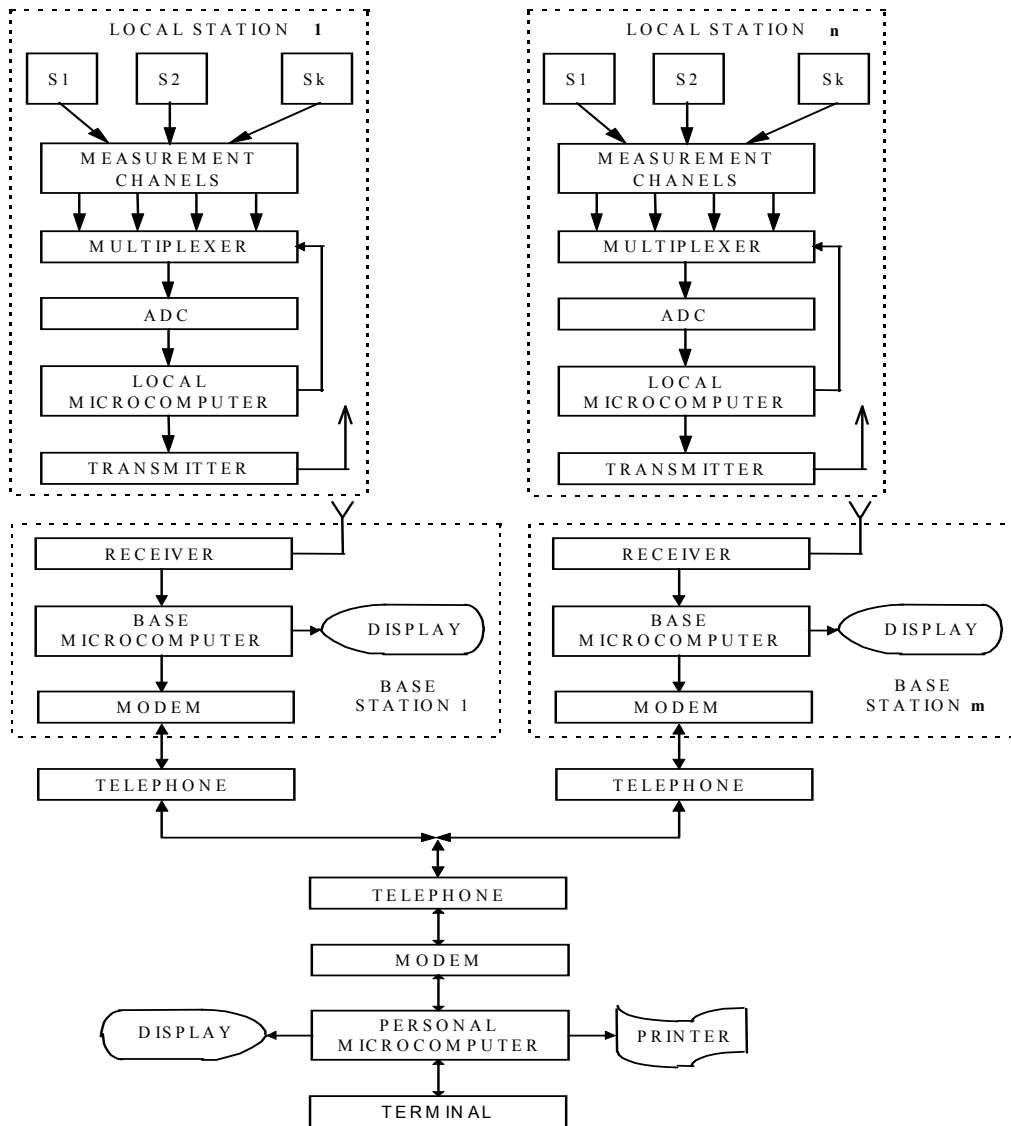


Figure 64. Block diagram of the microcomputer measurement system structure

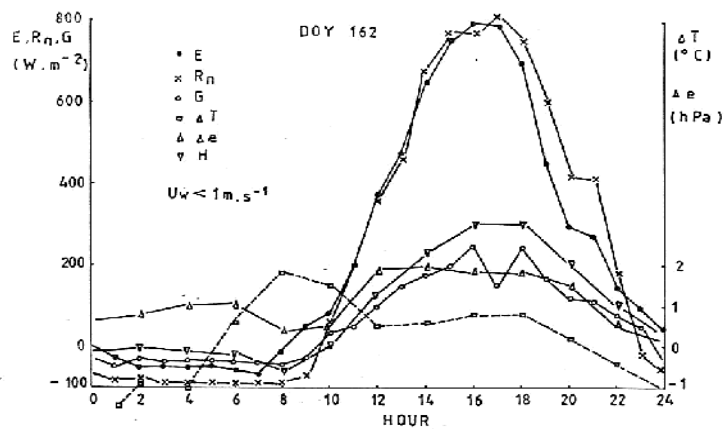


Figure 65. Diurnal curves of the evapotranspiration and other heat balance elements registered by one local station of the system in the Razgrad region

Having the data and information collected by microcomputer meteorological systems agronomists can monitor the dynamics of the processes in the field and their influence on crop growth, plant diseases, insect activity, crop water stress, etc. Direct measurements of relative humidity and temperature differences in the field allow calculation of heat balance elements and evapotranspiration. The agrometeorological systems described are very sophisticated devices designed to operate automatically all year round.

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Canopy structure is another factor setting restrictions on the homogeneity of the soil properties. The soil temperature and the soil moisture, for example, differ under the plants and between the rows of row-crop canopies, and depend on the fraction of soil surface exposed to direct sunlight. The area of this fraction can be calculated based on the relationship between the sunlight transpiration, leaf area index and leaf angle distribution. The concept of this relationship can be approximated by Beer's Law.

The soil surface temperature in the regions  $H_i$  is  $T_s^1$  and in the regions  $L_i$  is  $T_s^2$ . Then:

$$(T_s^1, T_s^2) = \varphi(f) \quad (1)$$

$$f = \exp(-k.LAI) \quad (2)$$

where  $f$  is the fraction of soil surface in direct sunlight,  $k$  is an absorption coefficient and LAI is the leaf area index. The coefficient  $k$  is a function of the canopy leaf angle distribution, random of the leaves and the sun zenith angle  $\theta$ . For a given sun angle,  $k$  represents the fraction of leaf area projected onto the soil surface. The latitude of Bulgaria is  $42^\circ\text{N}$ , and the solar zenith angle,  $\theta$ , changes from  $30^\circ$  to  $70^\circ$  during the active agricultural season.

For canopies where the foliage is horizontally homogeneous, the absorption coefficient is:

$$k = \int_0^{\pi/2} \frac{g(\alpha) \cdot \cos \delta}{\cos \theta} d\alpha \quad (3)$$

where  $\alpha$  is the angle between the leaf normal and the vertical,  $\delta$  is the angle between the normal to the leaf surface and the incoming ray of sunlight, and  $g(\alpha)$  is the density function of leaf normals with the vertical.

Combining eq.2 and eq.3, the fraction of soil surface in direct sunlight becomes:

$$f = \exp(-LAI \int_0^{\pi/2} \frac{g(\alpha) \cdot \cos \delta}{\cos \theta} d\alpha) \quad (4)$$

Equation (4) defines the integral relationship between canopy structure and area of soil surface in direct sunlight. This equation is based on the assumptions of an uniform distribution of leaf azimuth angles and homogeneous positioning of the foliage in the horizontal.

To solve equations (1) and (4) for the unknowns  $g(\alpha)$  and LAI, the fraction  $f$ , can be measured at various sun angles  $\theta$ , and a system of integral equations be defined. The leaf angle distribution and

leaf area index LAI can be estimated using methodology of direct measurement of canopy structure, described by [Perry et al, 1988].

### 4.3 Portable device "Floratest" for express-diagnostics of photosynthesis

In the context of the program of Presidium of National Academy of Sciences of Ukraine (NASU) "Development in the field of sensor systems and technology" in Glushkov's Institute of Cybernetics of NASU there was developed portable smart device "Floratest" for express-diagnostics of influence of stress factors on the plant's state [Romanov et al, 2007]. The portable device measures chlorophyll fluorescence induction (CFI) without plant destruction. Using the curve of CFI (alike the cardiogram) allows diagnosing influence of one or other influential factor on the plant's state.

#### 4.3.1 Principles of device operation

As a result of external influence, different objects, including biological ones, can generate plenty of radiation that is independent of these objects temperature.

All the types of radiation that were caused by some external sources of energy are called luminescence. Duration of luminescence after external influence stopping exceeds period of light fluctuations. Luminescence is conditioned by fluctuations of relatively small number of atoms or molecules of substance that become excited under energy source activity. Radiation is a result of transformation of atoms' or molecules' states into fundamental (unexcited) or less excited (they have less energy) states.

This is well adjusted with quantum theory, according to what every stationary orbit conforms to definite value of atom's energy (Bore's postulate). Being placed on stationary orbits an electron does not radiate and does not absorb electromagnetic waves. According to the second Bore's postulate radiation and absorption can happen only when atom changes its state from one stationary state to another:

$$h\varpi_{mn} = h\nu_{mn} = E_n - E_m \quad (5)$$

where  $\varpi_{mn}$  or  $\nu_{mn}$  – photon's frequency,  $E_m, E_n$  – energy values of the states  $m$  and  $n$ ,  $h$  – Planck's constant,  $m$  and  $n$  – the numbers of energy states. At the same time electron switches from one stationary orbit to another.

Luminescence is defined by the structure of substance energy spectrum, the average time of staying in excited states and rules of selection, which allow absorption or radiation of light of defined frequency. Short-timed luminescence is also called fluorescence. Luminescence, which appears during lighting of substance (phosphor) with visible or ultraviolet light, is called photoluminescence. Usually process of luminescence satisfies Stocks' rule that claims that wavelength  $\lambda'$  of radiated light is greater than wave  $\lambda$  of excited light. According to the quantum theory, this means that photon's energy  $h\varpi(h\nu)$  is used partially for non-optical processes:

$$h\varpi = h\varpi' + E, \varpi > \varpi' \quad (6)$$

where  $\varpi'$  – luminescence's frequency,  $E$  – energy waste on another process.

Luminescence is characterized by energy output, which equals to ratio of luminescence energy to energy that was absorbed by substance under stationary conditions.

Energy efficiency of photoluminescence increases proportionally to wave length  $\lambda$  of absorbed light up to the definite maximum value at  $\lambda = \lambda_{\max}$  and then rapidly decreases to zero at  $\lambda > \lambda_{\max}$  (Vavilov's rule). A sharp decrease of energy at  $\lambda > \lambda_{\max}$  is explained by the fact that at these wavelengths  $\lambda$  the energy of absorbed photons is not enough for the process of phosphor atoms and molecules transfer to the excited states.

Ratio of luminescence photons number to absorbed photons with fixed energy is called quantum yield of photoluminescence. According to Vavilov's rule, which is under Stocks' rule, quantum yield of photoluminescence does not depend on wavelength of excited light and rapidly decreases for anti-Stocks radiation.

Intensity of luminescence  $I$  depends on behavior of elementary processes that causes this radiation. In case of spontaneous luminescence, when radiation starts after light absorption during which atoms or molecules are transmitted to the excited level that is placed higher than the level at which radiation takes place and then these atoms (molecules) are transmitted to the luminescence level, intensity is subordinate to exponential rule

$$I = I_0 \exp(-t/\tau) \quad (7)$$

where  $I$  – lighting intensity at the moment  $t$ ,  $I_0$  – lighting intensity in a moment of excited radiation stopping,  $\tau \approx 10^{-9} - 10^{-8}$  sec – an average duration of excited state of phosphor atoms or molecules. Luminescence of compound molecules and phosphorescence (after lighting) of organic substance are subordinate to the law (7).

Under influence of light there can be happened photochemical transformation of substance (including photosynthesis), which is called photochemical reactions. In a process of such reactions, light absorption takes place. Energy is spent on compound molecules and polyatomic ions decomposition to component parts and creation of compound molecules of primary ones. An example of photochemical reactions is decomposition carbon dioxide under influence of light



Carbon dioxide decomposition takes place in green parts of plants under sun light influence, as photochemical process, which is a part of photosynthesis.

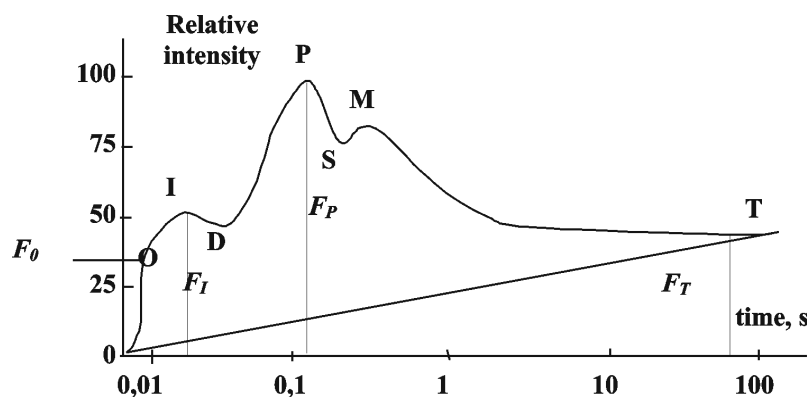


Figure 66. Chlorophyll fluorescence induction curve

One of the most important properties of the molecule of chlorophyll, which is the basic pigment of plant cell, is ability to fluoresce. For the first time this phenomenon was researched by Kautsky [Kautsky and Hirsch, 1931; 1934]. Dependence of chlorophyll fluorescence induction on time passed



after start of lightning of plant's leaves is known as an induction curve or a chlorophyll fluorescence induction curve (Figure 66). The form of this curve is rather sensible to changes in the photosynthetic apparatus of plants during adaptation to different environmental conditions. This fact is a basic for extensive usage of Kautsky effect in photosynthesis research. The advantages of the method of CFI are the following: high self-descriptiveness, expressiveness, noninvasiveness, and high sensibility.

Abilities to estimate plants states using changing of Kautsky curve form are experimentally verified. Therefore, there are examples of changing form of this curve under influence external factors.

**Increase of environment temperature** relative to optimal for definite plant type causes decreasing of difference  $F_V = F_P - F_0$ . The reason is decreasing of activity of electron-transport chain or lighting activity of photosynthesis. During increasing of temperature to destruction level (45–50 °C), the level of intensity  $F_0$  increases noticeable. It is possible to choose plants sort that are stable to high temperature influence using these parameters.

**Decreasing of environments' temperature** relative to optimal for definite plant type causes also decreasing of difference  $F_V = F_P - F_0$ , because of oppression of photochemical activity photosystem PSII. Ratio  $(F_1 - F_0) / F_V$  is increasing. These features allow selecting cold-resistant plants.

**Salinity of ground** results in decreasing of level of  $F_P$  and  $F_0$ . Ratio  $(F_P - F_0) / F_P$  is decreasing. Reason of that is oppressing of photo system PSII activity. Using these features, it is possible to choose plants that are stable ground salinity.

**Water deficit** results in decreasing of subtraction  $F_P - F_0$  in direct proportion with decreasing of water potential of leaf. Most probable reason is slowing down of photo system PSII recovery of primary acceptor because of oppression of excretion oxygen and intersystem transport of electrons.

#### 4.3.2 Device features

Device and relevant diagnostic methods refer to the area of biological object researches by detecting their biophysical properties, particularly native chlorophyll fluorescent induction. Device is defined as smart biosensor with fragment plant as sensing element.

Express diagnostic of plant state is carried out by functional features and is based on using of features of separate specific sections of IFC curve, which refer to separate areas of photosynthesis chains as diagnostic features. By IFC curve form, it is easily to detect influence of one or another factor on the plant state.

Appearance of portable device "Floratest" is shown on the Figure 67.

Application areas of portable device for express-diagnostics of plant state:

- express-estimating of plant vital activity after drought, frosts, sorts coupling, pesticide introduction;
- express-detection of optimal doses of chemical fertilizers and biological additives, what lets to optimize amount of fertilizers and additives and reduce nitrates content in vegetables and fruits;

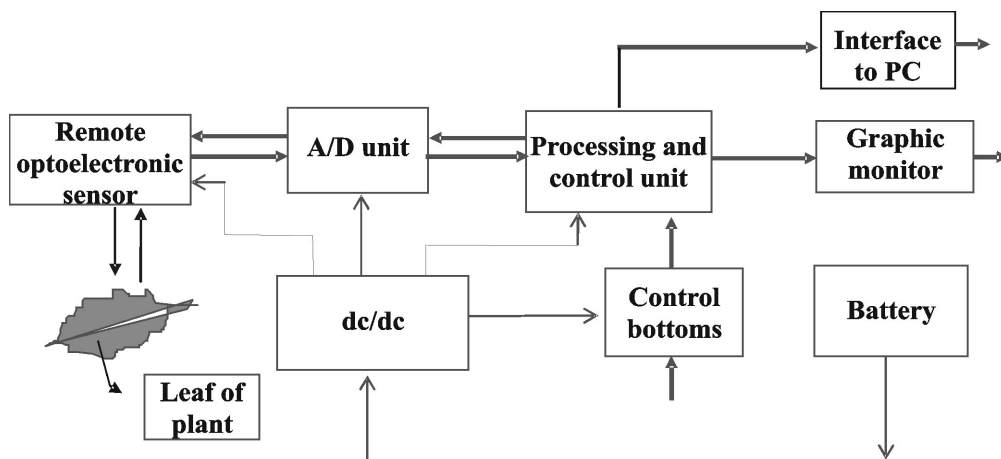


Figure 67. Appearance of portable device "Floratest"

- express-detection of level of pollution of water, soil and air by pesticides, heavy metals and superpoison;
- economy of energetic and water resources during man-made watering;
- developing of precision agriculture technology for increasing the quality of agricultural products;
- using of the device in the insurance agriculture to get predicted results of future yield;
- automation of researches in the plant physiology field.

Functional diagram of the device is shown on the Figure 68. Data processing unit and displaying unit are built on the base of micro converter ADuC842 and graphical display with resolution capability of 128\*64 pixels. Micro converter is system-on-chip for data acquisition and processing, which includes analog-digital and digital-analog converters, reference supplies, temperature sensor, timers, power supply monitor, embedded industry standard 8052 microcontroller, external and internal data memory, program memory etc.

Remote optical sensor is built as "reflection diagram" on the base of four light-emitting diodes and one photodetector. "Reflection diagram" means that light-emitting diodes and photodetector are situated from the same side of researched leaf. To research chlorophyll fluorescence in the red spectral region the filter is placed on the input of photodetector. Emission intensity of light-emitting diodes and photodetector sensitivity can be changed during measuring process. Integrated algorithm of device work is shown on the Figure 69.



**Figure 68. Functional diagram of portable device "Floratest"**

Today it is not enough to acquire and save measurement result in the portable device memory. It is urgent to transmit measurement results from places of measurement to laboratories or centers of operative estimation of condition and necessary decision-making. For data transmitting from measuring channel to receiving point, it is proposed to use mobile communication by means of midget GSM-unit with GPS-subsystem, which is embedded in the portable device, and GSM-modem, which is connected to computer or workstation. During such measurements, the transmissions of a small amount of data are required, so it is reasonable to use GPRS standard. Data acquiring, processing, and transmitting system on the base of portable device with radio channel is shown on the Figure 70.

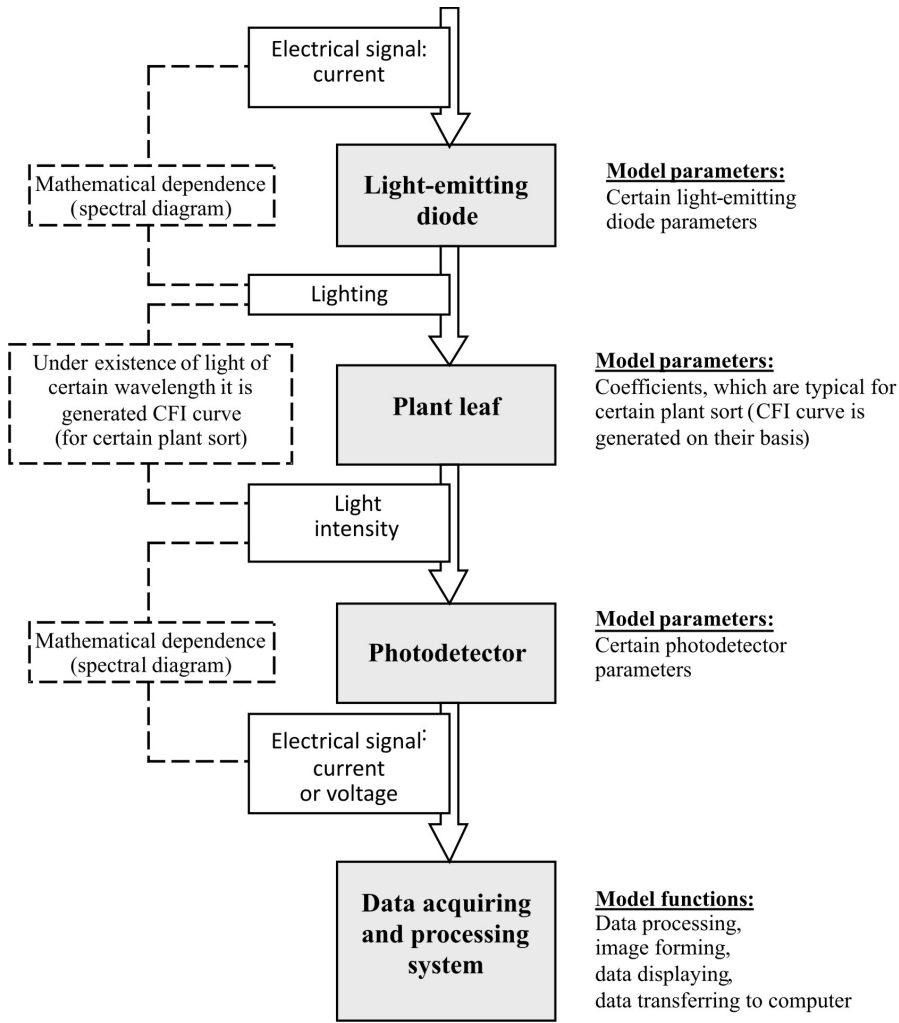


Figure 69. Integrated algorithm of device work and proper models

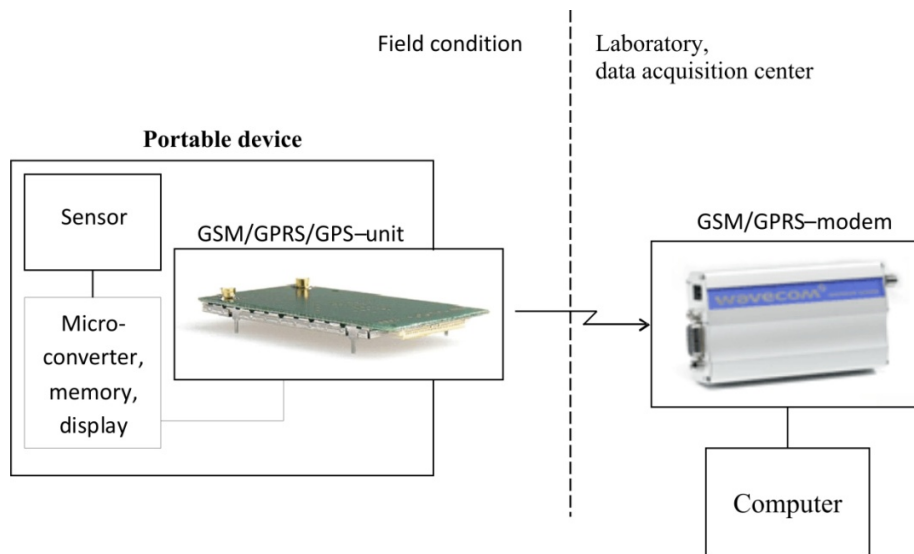
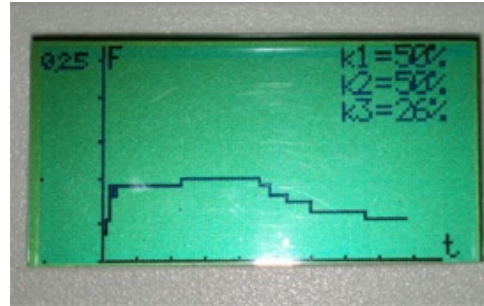


Figure 70. Data acquiring, processing and transmitting system on the base of portable device with radio channel

### 4.3.3 Device application

The experimental researches of the "Floratest" were conducted in National Scientific Center "V.E.Tairov's Institute of viticulture and winemaking" of Academy of Agrarian Sciences of Ukraine [Romanov et al, 2007].

Examples of the practical usage of fluorometer "Floratest" in the National Scientific Center "V.E.Tairov's Institute of viticulture and winemaking" are shown on Figure 71 and the graph of CFI on the device display are shown on Figure 72.



**Figure 71. The sensor of the "Floratest" on the vine leaf**    **Figure 72. The image of CFI on the device's display**

The conditions and results of the experimental researches are listed below.

Mature leaves of vine were used in the researches. Under changes of soil watering conditions there were observed sharp changes in behavior of induction transitions of chlorophyll fluorescence which were accompanied by quite essential changes of leaf tissue spectral characteristics.

Determination of fluorescence spectral characteristics was done by placing the device's sensor on the leaf's surface without integrity disturbance directly in a pot or in a field. It allowed to research on plastid and vacuolar pigments in their natural state and in that way approaching to understanding of the biophysical and physiology-biochemical processes which take place in the live leaf, and determination of important sides of photosynthetic activity.

Fluorescence intensity of the sample was determined in relative units.

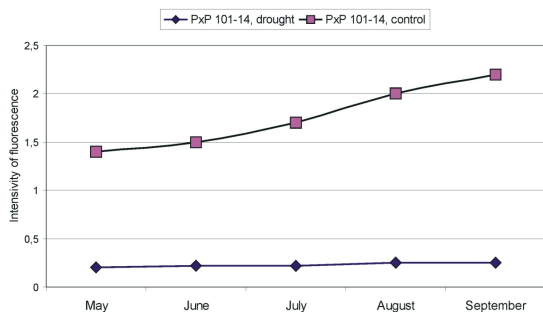
It is significant that under natural conditions in the middle latitudes the drought is accompanied simultaneously by high temperatures of air, and that intensifies bad influence of ground water lack on agricultural plants.

Even in the first variant of experiment (drought) there appeared considerable changes of the behavior of fluorescence induction comparing to the control samples. Changes show in weakening of penetrability of the chloroplasts' membrane structures. That results in substantial increase of time characteristics of fluorescence induction slow decrease. At the same time noticeable variety differences become apparent. Sharp decrease of its value is typical for profound functional injuries of photosynthetic structures and cells of particular variety entirely.

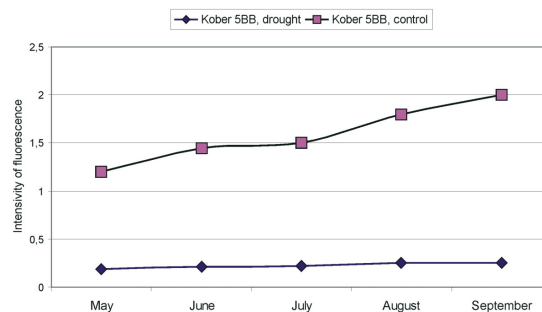
Accordingly in this stage of drought influence, significant variety differences in exsiccate factor resistance of both photosynthetic structures and lamina's parenchymal cells entirely became apparent.

More deep changes of destructive nature may be observed in case of high temperatures (+40 °C), which influence on leaves complementary to drought. In this case, for all the varieties being studied significant and almost irreversible functional changes of plastid structures are noted. These functional changes show in sharp decrease of CFI intensity.

Disastrous changes of life activity of vine leaf cells, which take place during these processes show in oppression of biosynthetic processes, intensive decomposition of cytoplasmic structures and intensification of oxide catabolism of plant cell's content. The consequence of these processes is decrease of CFI intensity because of its oxidizing transformation.



**Figure 73. CFI intensity of vine plant (sort PxP 101-14) under drought and normal conditions**



**Figure 74. CFI intensity of vine plant (Kober 5BB) under drought and normal conditions**

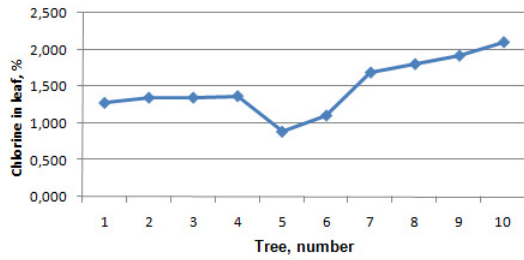
On the Figure 73 and Figure 74 there are shown the diagrams of measuring of chlorophyll fluorescence intensity for two sorts of vine plants (PxP 101-14 and Kober 5BB) during 5 months. The vine plants were under drought influence and normal conditions.

Thus, a water deficit shows up on the Kautsky curve as difference of fluorescence ( $F_p - F_0$ ) decrease. The most credible reason of this is oppression of oxygen emission, which is related with slowing down of electrons transfer. Assuming that  $F_0$  almost does not change for the test and control plants, in a maximum point the chlorophyll fluorescence intensity value can define the level of water deficit.

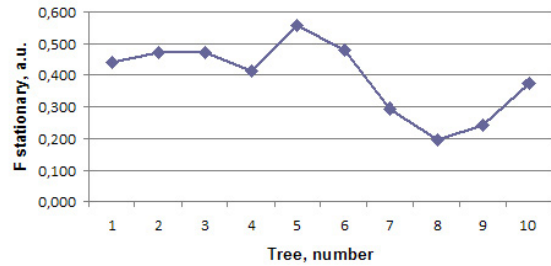
In 2008 together with Megalopolis Ecomonitoring and Biodiversity Research Center of National Academy of Sciences of Ukraine experimental researches of portable device "Floratest" were carried out to detect influence of heavy metals and harmful substances (e.g. lead, sodium, chlorine etc.) in leaf and soil on the plants state in Kiev. Today long-term phytomonitoring methods are used. They consist of visual observations and chemical analysis of soils and plant fragments, and needs complicated equipments and lasts more than one week.

Long duration and complexity of existing methods of heavy metals and harmful substances detecting in live plants and necessity to involve skilled specialists to perform these researches set necessary conditions to develop special diagnostic methods and tools for this aim. Preliminary researches indicate that portable device "Floratest" can be used for detecting of heavy metals and harmful substances influence on state of plants by measuring of CFI curve. The form of CFI curve changes versus level of harmful substances influence.

Joint researches were carried out in Kiev green regions by means of common phytomonitoring methods and portable device "Floratest". After processing of research result there were built dependences for searching correlations between chlorine content in trees' leaf, which are got by common phytomonitoring methods (Figure 75), and readouts of portable device "Floratest" (Figure 76). Even one can see some dependence between chlorine content in trees' leaf and readouts of portable device "Floratest" (stationary region of IFC curve). Calculations, made by mathematical methods, show certain correlations between these values. Such researches were made for other harmful substances, such as sodium, magnesium.



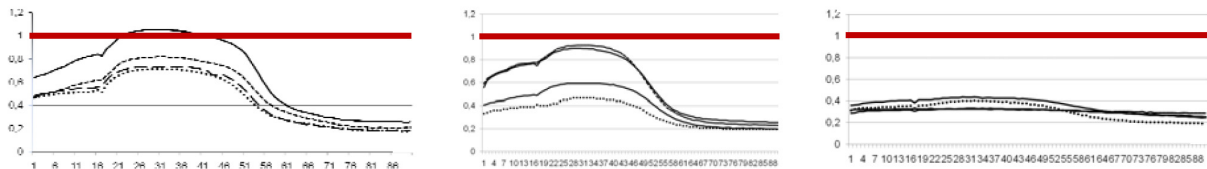
**Figure 75. Chlorine content in researched trees' leaf**



**Figure 76. Readouts for researched trees**

It is easily to concede that IFC curve form expresses not only contents of separate harmful substance, but general state of tree versus influence level of harmful substances.

Researches of developing smart biosensor device "Floratest" for detecting of water deficit of plants were executed in the National scientific centre "Institute of viticulture and wine-making named after V.Ye.Tairov" of National academy of agrarian sciences of Ukraine (see Figure 77).



*(a) before predrying (b) after 10 hours of predrying (c) after 24 hours of predrying*

**Figure 77. Measuring chlorophyll fluorescence induction curve**

## 4.4 Discussion

A way to manage electronic measurements for evaluation of soil properties at heterogeneous fields based on tree-root method and a single representative area has been presented. Gypsum blocks for soil moisture and temperature, and salinity sensors, interfaced to alternating current bridge made at "Nikola Poushkarov" Institute, proved to be useful in soil profile temperature and moisture measurements and in determination of the soil heat, water, and solution fluxes following rain or irrigation and fertilization. These measurements in single representative areas, combined with space distributed soil surface measurements done by an infrared thermometer can be widely used to evaluate the main components of the heat and water budget of the heterogeneous agricultural field.

The structure of the microcomputer measurement systems submitted above suggests a direct and correct estimation of the evapotranspiration from the system "soil-grass and trees-atmosphere", based on space distributed continuous measurements. The determination of the evapotranspiration by the energy balance method using the Bowen ratio allows for measuring only some of the heat and water balance elements. The ever-changing fluctuations in environmental conditions need a relatively large instrumental effort. Measurements carried out by microcomputer systems and analysis of the data obtained showed that such systems could be useful both for the research and for

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practice. The possibility of creating a large microclimatic database of the forests for long periods contributes to a careful study of these territories.

In Glushkov's Institute of Cybernetics of NAS of Ukraine there was developed portable smart device "Floratest" for express-diagnostics of influence of stress factors on the plant's state. The portable device measures chlorophyll fluorescence induction without plant destruction. Using the curve of chlorophyll fluorescence induction (alike the cardiogram) allows diagnosing influence of one or other influential factor on the plant's state. On basis of preliminary researches there were shown that using of portable device "Floratest" let to detect in express mode the worsening of photosynthetic apparatus of plant by measuring fluorescence of native chlorophyll on the early stages. During experimental researches, there were developed methodical tools, which allow evaluating the state of vine plants under drought conditions and conditions of insufficient water capacity in express-mode.