Framework concept of the project "The ancient wheat: growth and physiological characteristics under unfavorable stress factors and possibilities to alleviate the negative effects"

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Framework concept of the project “The ancient wheat - growth and physiological characteristics under unfavorable stress factors and possibilities to alleviate the negative effects”

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ABSTRACT

The project “The ancient wheat - growth and physiological characteristics under unfavorable stress factors and possibilities to alleviate the negative effects” is in line with the scientific priorities of the Bulgarian National Research Strategy: Improvement of the quality of life – food, environment protection, with the EU FP „Horizon Europe": Food, bioeconomy, agriculture & environment, and with launching an International Research Initiative for Wheat Improvement. This initiative is based on the urgent need for all countries to speed the progress in wheat in relation to its productivity, adaptivity, stress tolerance and efficient use of nutrients. In the same time the project match the objectives of the European Space Strategy and the European Space Policy - to support the appropriate research activities fostering the exploitation of the technical capabilities of the space community with the objective of seizing market opportunities and meeting the demands of the society. The project's goal is to use the technical capabilities for spectral measurements in remote sensing monitoring of wheat crops under unfavorable stress factors that is relevant to the European Policies in the domain of the most advances information technologies. Aiming optimal combination, integration and dissemination of data and services, the project will create further interdisciplinary perspectives. Spectral measurement data will enable the validation of information products with respect to the accuracy and reliability of the data. The planned spectral measurements and the acquired data closely correspond to the "Copernicus" program. The remotely sensing obtained data will be used for knowledge upgrading about relation between unfavorable stress factors and spectral data. This will contribute to the widespread dissemination of scientific results and will be used to link space remote monitoring and ground-truth data. This work is supported by the Bulgarian National Science Fund under Project KP-06-N56/15 (КП-06-Н56/15).

Keywords: research project, Earth Observation, Remote Sensing, stress factors

1. INTRODUCTION

Wheat is one of the main food sources in the world and is a major crop in the contemporary agriculture. During the second half of the XX-th Century, there was a significant intensification in wheat growing. This increasing in wheat production was achieved by introduction of new varieties with higher yield and environmental stress tolerance. However, the nutritional value of the grain of such varieties was usually not satisfactory. Nowadays, the increased interest to healthful nutrition as a base for higher quality of life, leads to increased demand of specialized food products based on alternative wheat species. Some of the first cultivated wheat species by humankind such as einkorn and emmer possess high nutritional value and better technological characteristics of the grain as compared to the common extensively grown wheat varieties.

In relation to the increasing European requirements for crop production with less synthetic pesticides and fertilizers, the exploitation of alternative wheat species appears to be a beneficial approach to the biological agriculture. The contemporary wheat varieties can not be used under such circumstances because they are adapted for conventional agriculture. Recently, the attention of the organic farmers is focused on varieties whose production is less pollutant, varieties which are more tolerant to unfavorable changes in the environment, and if possible to be grown without additional fertilizers.

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The evolutionary older wheat species populate mainly mountainous regions, which supposes that they could be more suitable to be grown on unfertile and arid soil, and could be better adaptable to rapid environmental changes. There are promising results with growing of einkorn in different regions of Bulgaria.[1]

Plants are subjected to various changing and overlapping abiotic and biotic natural or anthropogenic stress factors. They disturb the normal physiological functions and cause injuries that could even lead to plant death. Recently the efforts of the specialists are applied in the search of possibilities to diminish the negative consequences of different stress factors. This could be achieved by development of new stress tolerant varieties. Another approach is by application of plant growth regulators or other substances, which can activate the defense systems of plants. This is a versatile tool to induce stress tolerance. It is known that a weak stress can induce a tolerance to a subsequent stronger stress, so called cross-tolerance[2].

The remote sensing methodology for analyzing state of different agricultural crops (barley, peas, alfalfa, and wheat) is developed in Remote Sensing Systems Department at Space Research and Technology Institute at the Bulgarian Academy of Sciences[3-12]. The team apply this methodology for the studying of the stress impact related to the cultivation of ancient wheat. The methodology is based on spectral reflectance data acquired using multichannel spectrometric systems and fusing data.[13-14]

The team of scientists from Space Research and Technology Institute at the Bulgarian Academy of Sciences supports the colleagues from Institute of Plant Physiology and Genetics at the Bulgarian Academy of Sciences combining these two complementary areas. The development of better criteria for the diagnosis and quantitative assessment of the stress impact on physiological development, biological productivity and ecological quality of plant production has led the team to applying of joint spectrometric and biochemical studies, combined methods and different data.

2. MATERIALS AND METHODS

2.1 Materials

To achieve the project goals, one alternative wheat species *Triticum monococcum* L. and one broadly used variety of conventional wheat (*Triticum aestivum* L. - the variety will be elected experimentally) will be compared for their tolerance to some of the most common for Bulgarian region stress factors. Seeds with proven origin are bought from the Institute of Plant Genetic Resources "K. Malkov" in Sadovo Town, Bulgaria.

During the initial stage of the project, plants are grown as water cultures under controlled conditions in climatic chamber (150 µmol.m^{-2}.s^{-1}, relative air humidity 60-70%, temperatures 25/20°C – day/night). The phases of treatments and sampling are established experimentally.

During the second stage of the project the plants will be grown in the field. The treatments will be carried out with the most promising compounds established during the first stage. The type of the trials will depend on the biological and agrotechnical features of the culture. Sowing will be made manually under observing agrotechnical terms. The experimental area for each wheat and einkorn wheat genotype will be 5 m^2 for variants, or a total will be 20 m^2 for a culture. During the development of the plants, the necessary agrotechnics will be observed according to standard methodology

The stress factors applied in the experiments:
1. Drought (PEG 6000).
2. Salinity (NaCl).
3. UV-B irradiation (relevant biologically effective dose).

Test compounds in the experiments are:
1. Derivatives of naturally occurring dicarboxylic acids - monomethyl ester of itaconic acid (MEIA).
2. Triacontanol.
3. Phenylurea cytokinin 4PU-30.

Treatments of the crops:
The test compounds are applied by leaf spraying alone or in combination before or after the stress. Drought and salinity stresses are applied by adding suitable concentrations of PEG 6000 or NaCl to the nutrition medium. UV-B treatment are carried out by UV lamps with specific peak emission in the UV-B range.

The variants for field experiments will be as follows:
Control-fertilized with ammonium nitrate and no primed with grow regulator
No fertilized with ammonium nitrate and no primed with grow regulator
Fertilized with ammonium nitrate and primed with grow regulator
No fertilized with ammonium nitrate and primed with grow regulator

2.2 Previous experience and methods

The choice of the test compounds is based on previous investigations done by members of the project team working in the Institute of Plant Physiology and Genetics at the Bulgarian Academy of Sciences, and the stress protective properties of some of them are proven in different model systems. The monomethyl ester of itaconic acid showed protective action against herbicide chlorsulphuron in maize[15] and against tomato mosaic virus in tomato[16]. It was found that the phenylurea cytokinin 4PU-30 renders protective action in maize against the herbicide glyphosate[17], priming with cytokinins enhances seed viability of wheat after low temperature storage[18].

At the same time, the members of the scientific team have a considerable expertise in the investigations and assessment of the impact of different biotic and abiotic stress factors (plant pathogens, low or high temperature, drought, ultraviolet radiation, heavy metals) together with the investigation of physiological action of a number of compounds with regulatory function (H_2O_2, phytohormones, herbicides) derivatives of naturally occurring plant metabolites.[16,18,19-22]

The effects of some derivatives of naturally occurring in plants dicarboxylic acids (monomehtyl esters of itaconic and succinic acid) have been discovered and patented by the Institute of Plant Physiology and Genetics. It was found that they increase the yield of economically important crops.[23] These plant growth regulators render protection against herbicides[24], biotic stress[16].

The experience of the specialists from Space Research and Technology Institute at the Bulgarian Academy of Sciences concentrates on design and development of the multichannel spectrometric systems and their usage for research on spectral reflectance of agricultural crops grown under stress conditions such as soil contamination with heavy metals, food deficit, water stress.[10,11,25]

The project predicts the creation of an archive with freely available data from laboratory and field spectrometric measurements using spectrometers with narrow spectral channels (also known as hyperspectral spectrometers). The results obtained in this way will allow the correct interpretation of other spectrometric data when performing regular monitoring of larger areas of the country, where the studied sites occupy the respective areas.

2.3 Laboratory and field spectrometric instruments

The planned spectrometric measurements are performed using laboratory and field spectrometers. The used spectrometric system works in the wavelengths covering the spectral ranges from the visible /VIS/ to the near infrared /NIR/. A Thematically oriented multichannel spectrometer /TOMS/ is used to measure spectral reflectance for establishing relation between spectral and biophysical parameters. TOMS system is assembled in Remote Sensing System Department at Space Research and Technology Institute at the Bulgarian Academy of Sciences in collaboration with Alabama State University USA[26,27]. TOMS covers the spectral range (400-900) nm and based on the one of the models of Ocean Optics Inc.[28] (Figure 1 and Figure 2) Spectrometric measurements in the first planned experiments on ancient wheat are made in laboratory conditions. The photos are shown on Figures 3-6.

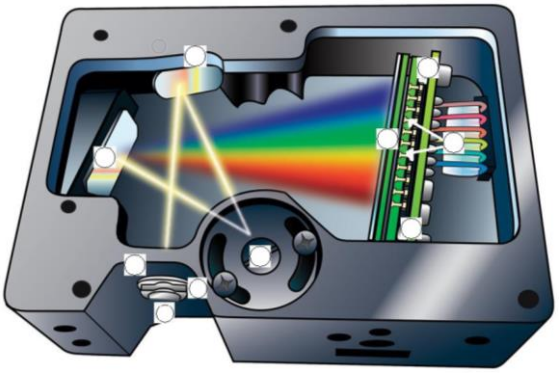

Figure 1. USB2000+ Spectrometer with Components[28]

Figure 2. USB4000 Fiber Optic Spectrometer[28]

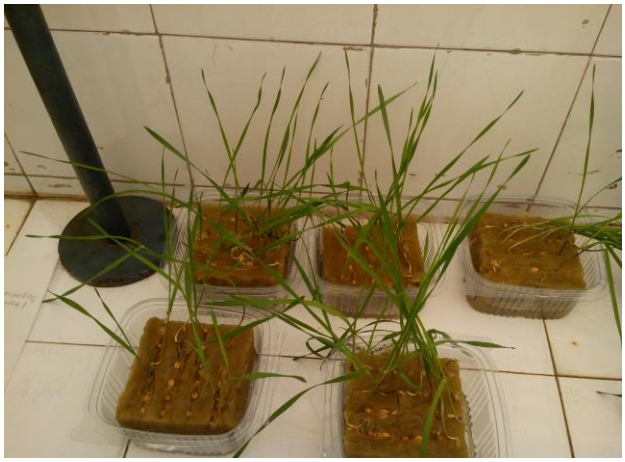

Figure 3. Growth of plants according stress parameters and treatments in climatic chamber and green house

Figure 4. Spectrometric measurements of plants in climatic chamber and green house

Figure 5. Growth of plants according stress parameters and treatments in laboratory

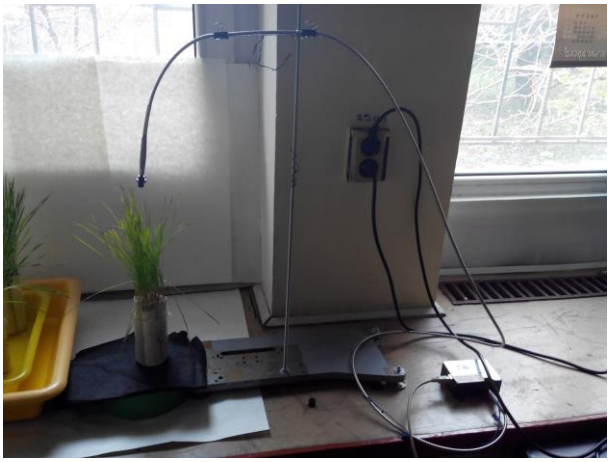

Figure 6. Spectrometric measurements of plants in laboratory

3. PRELIMINARY RESULTS

The first row spectral data are shown on the Figures 7 and 8. The data presented on Figure 7 are acquired by USB2000 spectrometer and on the Figure 8 are data obtained by USB4000 spectrometer.

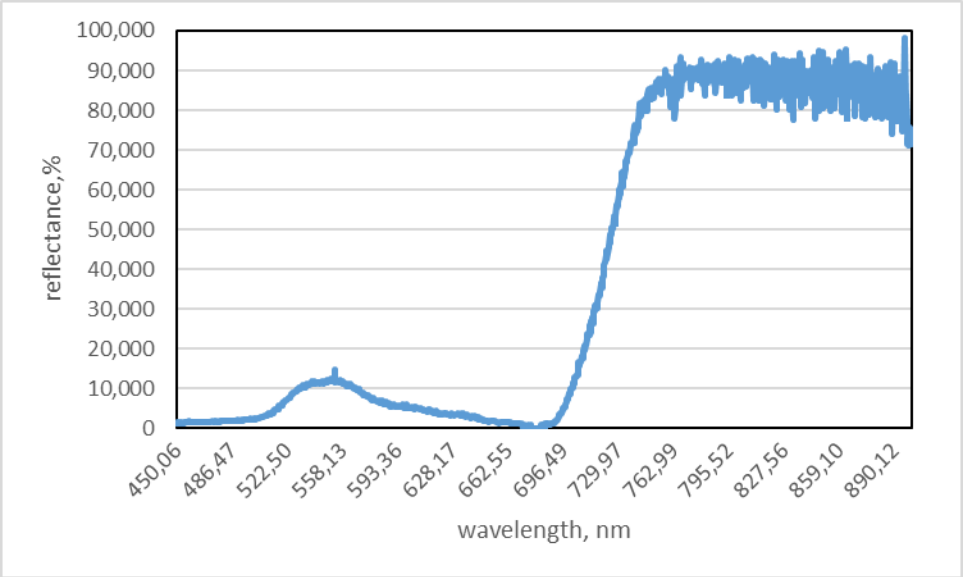

Figure 7. Spectral reflectance dependence of wavelength – USB2000 data

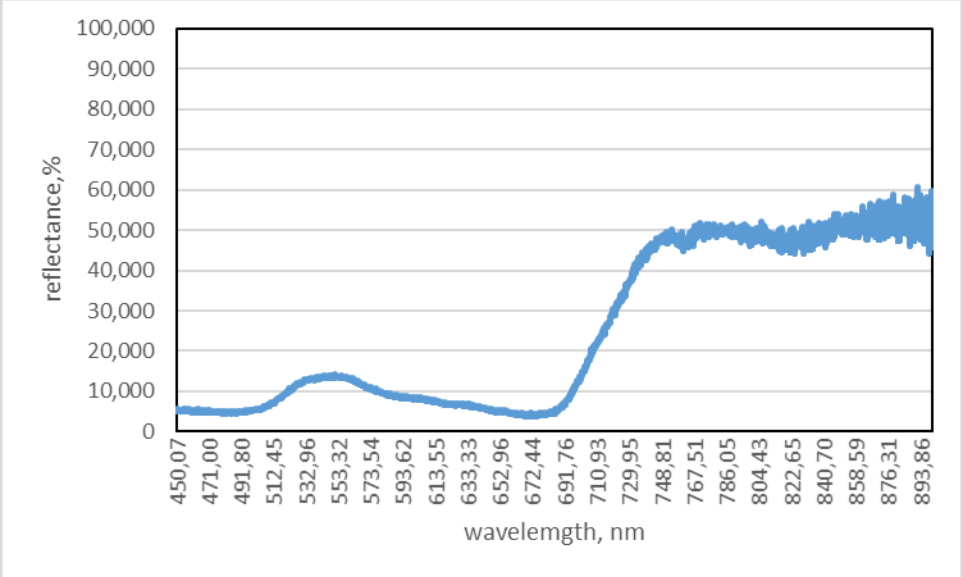

Figure 8. Spectral reflectance dependence of wavelength – USB4000 data

4. FIRST CONCLUSIONS

Spectral data will enable the validation of information products with respect to the accuracy and reliability of the data. The spectrometric measurements and the acquired data closely correspond to the "Copernicus" program. The remotely sensing obtained data are in processing for knowledge upgrading about relation between unfavorable stress factors and spectral data.

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