Daily dynamics of biopotentials of wheat sprouts under temperature impact

G V Seroklinov¹ and A V Gunko²

¹Siberian Federal Scientific Center of AgroBioTechnology, Russian Academy of Sciences, Krasnoobsk, Novosibirsk region, Russia
²Novosibirsk State Technical University, Novosibirsk, Russia
e-mail: seroklinov@mail.ru

Abstract This article discusses the methodology and results of experimental studies of monitoring the biopotentials of plants in the process of their growth using the example of wheat seedlings when exposed to high and low temperatures. The technique of preliminary processing of the obtained realizations of changes in biopotentials and the results of statistical studies are presented. The regression dependence of the biopotential of wheat seedlings "Novosibirskaya 41" under the influence of high and low temperatures on the age of these plants was obtained.

Keywords: biopotential, stressors, temperature, monitoring, plant age.

As known, when a plant is exposed to various stressors, for example, temperature, changes in biopotentials occur in it, which cause functional changes in the life of the plant. In the study of the biopotentials of cereal crops [1], it was found that the signals measured with an automated measuring complex [2] may differ significantly for different samples of the same species and variety. This difference may be due to both the individual characteristics of this sample and the physical conditions of the experiment. For example, the location of the electrode, loose contact or different distances between the electrodes, the age of the plant, and other reasons. As a result, the experimental data obtained have a significant scatter, which leads to significant differences in the information-significant parameters of the samples under study. An increase in the statistical significance of research results requires an increase in the sample size, which leads to an increase in material and time costs. This paper discusses the results of the effect of the age of wheat seedlings (objects of study) on changes in the biopotential during the experiments and the possibility of correcting the results obtained taking it into account.

There is an assumption that all electrical signal-induced functional changes depend on plant metabolism and change during the seedling stage during growth. It was shown that a quick and short-term increase in plant resistance to stress factors (several minutes after stimulation) is the end result of functional changes induced by electrical signals [3]. In this regard, the biopotentials arising from the effects on seedlings of different ages will be formed under the conditions of the functional changes in the plant's vital activity and will differ. This should contribute to the difference in the change in biopotential for different plant samples of different ages of the same cultivar. Therefore, it can be assumed that when the experiment (measurement) is repeated for an older plant, the biopotential signal will differ from the previously measured one.
Experimental studies to assess the effect of the age of seedlings on the biopotentials of plants when exposed to temperature were carried out using the automated system for experimental studies "AutoExpI" [2], developed for the study of biological structures at the Siberian Institute of Physics and Technology, SFSCA RAS and additionally equipped with a device for forming a temperature profile (UVTP). The UVTP is made on the basis of the Peltier element and allows the formation of various temperature profiles that affect the plants placed on the laboratory table.

The studies were carried out under the following conditions. The plant was placed on a UVTP laboratory thermostat shown in Figure 1.

By the nature of the arrangement of the electrodes in the installation, a unipolar method of AP removal was used. With this method, one electrode (measuring) is located on the surface of the shoot of the seedling, and the second is the reference electrode in the area of its roots (in a cuvette with a nutrient solution). The place of contact between the sensor and the plant, to improve contact, is lubricated with an electrically conductive gel or moistened with tap water. The laboratory table with the experimental plant was placed in a climatic chamber, the air temperature in which was set at 20 ± 1 °C. The same temperature was set in the temperature zone of the laboratory table.

The experiment was carried out in the following order. The automated system for experimental research "AutoExpI" was turned on. From the keyboard of the PC of the system, a cycle of measurement of PD and temperature was started in accordance with the algorithm laid down in the computer program, according to which, 6 seconds after starting, the formation of a given temperature profile affecting the plant was started. The signals obtained as a result of measuring the biopotential of the seedling and the

![Figure 1. General view of the laboratory table](image)

![Figure 2. Graph of the temperature profile with the specified parameters at the temperature value; a - 40 °C, b - 5 °C](image)
current temperature during the entire time of measurement were recorded in the database. The measurement algorithm provided for picking up and recording changing signals of biopotential (plant response to stimulus) and temperature for 160 seconds. Experimental studies were carried out on seedlings of wheat variety "Novosibirskaya 41" aged from 10 to 19 days, which were exposed to high and low temperatures, the profiles of which are shown in Figure 2. The experiments were carried out on 10 plants that were grown and kept in the climatic chamber "Biotron-8 » in laboratory conditions during the research period.

The obtained experimental data were exported to the Matlab environment and processed using algorithms using vectorized calculations. In the process of preprocessing, the implementation of the recorded PD signal was filtered, the average value of the steady-state signal value ((Uav. set) until the moment of exposure to the plant (5.3–5.8 sec)) was calculated, the signal was centered, the signal was normalized by temperature, and the rate of its change (signal differentiation). As the defining parameters on the realizations obtained in the course of processing, the following were taken: the minimum (Umin) and maximum (Umax) signal values during and after the exposure of plants to temperature changes in the interval (7.5–157 sec). When processing the results of the preliminary analysis, the signals Umax and Umin were centered according to the expressions:

$$U_{\text{max}, c} = U_{\text{max}} - U_{\text{av. set}}; \quad U_{\text{min}, c} = U_{\text{min}} - U_{\text{av. set}}.$$  

As a result, the absolute values of plant biopotentials were obtained, characterizing their response to external influences (stressors), which were used in the subsequent statistical analysis. In the course of the statistical processing, the following were determined: the mean value of the absolute value of the seedling biopotential, its mean deviation and variance at different ages. The calculation results are shown in Table 1 - for an increased temperature and in Table 2 - for a reduced one.

**Table 1. Statistical indicators of daily changes in the biopotentials of wheat seedlings "Novosibirskaya 41" under the influence of elevated temperatures.**

| Time (days) | 10   | 12   | 14   | 17   | 19   |
|------------|------|------|------|------|------|
| Average value | 0.00827 | 0.00623 | 0.00504 | 0.00421 | 0.00391 |
| Average deviation | 0.00311 | 0.00122 | 0.00124 | 0.00122 | 0.00047 |
| Dispersion | 0.00001 | 0.000003 | 0.00048 | 0.000003 | 0.0000005 |

**Table 2. Statistical indicators of daily changes in the biopotentials of wheat seedlings "Novosibirskaya 41" when exposed to low temperatures.**

| Time (days) | 10   | 12   | 14   | 17   | 19   |
|------------|------|------|------|------|------|
| Average value | 0.01332 | 0.01201 | 0.01533 | 0.02280 | 0.02086 |
| Average deviation | 0.00639 | 0.00499 | 0.00916 | 0.00908 | 0.01333 |
| Dispersion | 0.00006 | 0.00004 | 0.00014 | 0.00015 | 0.00025 |
Based on the results obtained, regression dependences of the average values of biopotentials of wheat seedlings "Novosibirskaya 41" under the influence of high and low temperatures on the age of plants were constructed. When exposed to elevated temperature, the dependence has the form:

\[ Y = 0.0261 - 0.0025\times + 6.8612\times10^{-5}\times x^2, \]  

(1)

where \( Y \) is the average value of \( U_{\text{max}} \) (V), \( x \) - seedling age (day). The graph of this dependence is shown in Figure 3.

When exposed to a low temperature, the dependence has the form:

\[ Y = 0.0464 - 0.0056\times + 0.0002\times^2, \]  

(2)

The graph of this dependence is shown in Figure 4.

![Figure 3. Graph of the dependence of the biopotential of wheat seedlings "Novosibirskaya 41" under the action of elevated temperatures from their age](image)

From the presented data and graphs of dependencies (1) and (2) of the averaged maximum values of seedling biopotentials under temperature influences, it can be seen that with a change in the age of plants, the level of their PD signal changes. The regression dependences obtained using the Statistics software are nonlinear (quadratic), falling when exposed to elevated temperatures and increasing when exposed to low temperatures.

Obtaining the presented results became possible due to the formation, in the course of experimental research, of identical disturbing influences generated by the new UFTV that were included in the automated complex for experimental research "AutoExpl". The results obtained also refute the earlier statements [4] that the age of seedlings does not have a significant effect on the value of biopotentials. Therefore, when carrying out long-term experiments with seedlings of cereal crops, it is necessary to take into account changes in the measured signals of biopotentials obtained on different days of the
experiment during the statistical processing of the data obtained. In addition, it is necessary to conduct studies similar to those presented in this work on other varieties of wheat and other cereals.

Thus, as a result of experimental studies of the values of biopotentials under the influence of low and high temperatures on wheat seedlings of the Novosibirskaya 41 variety, the presence of a dependence of the value of biopotentials on the age of the object (seedling), which is exposed, was shown. The dependences obtained from the research results have a quadratic dependence, which decreases when exposed to elevated temperatures and increases when exposed to low temperatures.

References

[1] Seroklinov G V and Gunko A V 2016 Information technologies in the study of plant biopotentials under the action of stressors Comp. techn 21 94-103
[2] Seroklinov G V, Gunko A V and Dobrovolskiy N A 2011 Software of the automated measuring complex Proc. St. Sc. Sib. Int. Phys. Techn. RAA on Methods and technical means of research of physical processes in agriculture (Novosibirsk: SibFTI) 152-156
[3] Surova L M 2017 The influence of the variable potential on the stability of the photosynthetic apparatus of the common pea (Pisum sativum L.): Dis. Cand. Bio. Sc. (Nizhny Novgorod: NNSU) 111
[4] Seroklinov G V and Gunko A V 2017 Adaptation of samples of cereal plants as a method of increasing the information content of data in experimental studies of biopotentials Coll. Art. AllRus. Sc. Prac. conf. with int. part. on Intellectual analysis of signals, data and knowledge: methods and tools (Novosibirsk: NSTU) 217-222