INFLUENCE OF SPRING TEMPERATURES AND SOIL HUMIDITY ON LEAVES TEMPERATURE GALANTHUS NIVALIS L. IN THE NATURAL ENVIRONMENT
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Abstract: *this article shows the results of a study early-spring influence air and soil temperature, soil humidity on the temperature of ephemeroid leaves Galanthus nivalis* L. *using the instruments Fluke Ti105, PMS 710 and DMLAS-1. The ability of snowdrop (G. nivalis) to raise the temperature of the leaves to +1.45 °C in the vegetative stage at a hypothermal temperature of soil –2.53 °C has been revealed. In the absence influence of stresses temperatures soil, the adaptive mechanism of the leaves was not activated.*

Keywords: *Galanthus nivalis, leaves temperature, soil temperature, leaves adaptation.*

ВЛИЯНИЕ ВЕСЕННИХ ТЕМПЕРАТУР И ВЛАЖНОСТИ ПОЧВЫ НА ТЕМПЕРАТУРУ ЛИСТЬЕВ GALANTHUS NIVALIS L. В ПРИРОДНОЙ ОКРУЖАЮЩЕЙ СРЕДЕ
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Аннотация: *в этой статье показаны результаты исследования ранневесеннего влияния температуры воздуха и почвы, влажности почвы на температуру эфемероидных листьев Galanthus nivalis* L. *с использованием приборов Fluke Ti105, PMS 710 и DMLAS-1. Выявлена способность подснежника (G. nivalis) повышать температуру листьев до +1,45 °C на вегетативном этапе при гипотермальной температуре почвы –2,53 °C. В отсутствие влияния стрессовых температур почвы адаптивный механизм листьев не активировался.*

Ключевые слова: *Galanthus nivalis, температура листьев, температура почвы, адаптация листьев.*

The growth intensity and development of different plant species various largely depends on the minimum, maximum and optimal values their thermal regime, which is confirmed by the results studies of cereal plants [1, 2]. The plants thermal regime is formed under the influence of radiation balance, heat exchange with atmospheric air and evaporation of moisture by plants [3].

According to the commission forecasts by 2100 the temperature of atmospheric air can rise by 5.4 °C [1], which will lead to the appearance of corresponding changes in soil temperature and moisture. In conditions insufficient soil moisture, due to higher air temperature and water deficit in leaves, stomata cells closes and assimilation slows down. At the same time, high solar radiation intensity can cause plant leaves overheating. With decreasing temperature of atmospheric air, the amount radiation solar, that plants are able to use without damaging their development, increases, but at temperatures below the biological minimum, especially at high soil moisture, putrefactive processes can be intensified in plants [3]. The existence connection between temperature, environment humidity and intensity plant leaves development is also indicated by the facts that, after exposure to low temperatures, structural changes occur in the root meristem that cause a slowing substances absorption down [4], damage leaves causes a decrease of photosynthesis intensity [5, 6] and growth enzymes activity [7], and at low relative environment humidity, growth slows down [8].

Research of adaptation frost-resistant plants to the influence of low temperatures atmospheric air, devoted is many works [9–11], in which the authors considerable attention to the quantitative characteristics evaluation of the development and functioning efficiency wild and agricultural plants. Wherein, the soil temperature influence on the development leaves of wild-growing early-spring ephemeroids, in which the leaves are located near the soil surface, remains insufficiently studied.

In our research attention was paid to detecting the relationship between the leaves temperature of the ephemeroid *G. nivalis* and the temperature, soil humidity, which, under natural conditions, varies considerably slower more in spring compared with atmospheric air temperature and, therefore, influence on the leaves longer.

In the experiment, *G. nivalis* plants were used, that developed in natural conditions in the open soil sites of Mokvinsky forestry, Rivne region, Ukraine. The area this relief is mostly flat, without significant hills and hollows. The surface soil layer this is gray-forest and dark-gray soils.

An investigation of temperature dynamics *G. nivalis* leaves was carried out without removing plants from the soil. Wherein, temperature of leaves, air, soil and relative humidity of the soil were compared at the vegetative stage, as well at budding and plants flowering.

With a traditional approach to measuring the leaves temperature and soil surface, several devices are used. A new approach at measuring the above-mentioned indicators was the application of the "Device for monitoring temperature of plants leaves and physic-climatic indicators of atmospheric air and soil (DMLAS-1)" [12], in which the programmed processor simultaneously carried out an automatic measurement of temperature atmospheric air and soil, the soil relative humidity and leaves temperature. Wherein, the measured data was automatically recorded and stored in the CSV-file format via the specified time interval. The measured values, obtained by the instrument, were compared with the measured data of the thermograph "Fluke Ti105" (USA) [13] and the soil moisture meter "PMS710" [14].

Temperature of *G. nivalis* leaves and soil surfaces was measured with the created "DMLAS-1" device, as well as the "Fluke Ti105" thermograph equipped with an infrared camera. On the received photo images, the measured points with their digital values of temperatures were displayed. By color of points (pixels) was identified features distribution values temperature of investigated objects.

Soil relative humidity was measured by the created device "DMLAS-1" and soil moisture meter "PMS710". At the experiment end, the results measurements, obtained by the "DMLAS-1" device were compared with the data obtained by the instruments "Fluke Ti105 Thermography" and "PMS710".

Results of the experiment, in the form of general and group sampling, were processed using the software tool Statistica 10.

The revealing possible air, soil, and soil moisture effects on the temperature of *G. nivalis* leaves were determined by comparing the average values of these parameters.

Since in the statistical samples the data had a non-normal distribution, calculations of the possible linear connection between the above-mentioned indexes were carried out using the Spearman method. Correlation was considered to be absent if its coefficient is approximate to 0 at a $p < 0.05$ level of confidence.

A study of effect air and soil temperature, soil surface moisture on the *G. nivalis* leaves temperature using the "Fluke Ti105" and "PMS 710" devices showed, that in the spring during the vegetative period and during the ephemeroides flowering, the mean values soil temperature surface varied from –2.53 to +5.14 °C, and the leaves temperature from +1.45 to +5.78 °C, air relative humidity from 72 to 83% (tabl. 1).

Table 1. The average values of the soil surface layer temperature and the leaves temperature G. nivalis in the natural environment during early-spring period

Parameters	**Measuring device**	**Development Stage**		
		Germination	**Budding**	**Flowering**
Surface soil layer temperature, ºC	Fluke 100	–2.53±0.257	+2.78±0.216	+5.14±0.271
	DMLAS-1	–2.56±0.319	+2.81±0.371	+5.17±0.357
Leaves temperature, ºC	Fluke 100	+1.45±0.204	+5.21±0.245	+5.78±0.269
	DMLAS-1	+1.40±0.328	+5.16±0.352	+5.73±0.331
Soil humidity, %	PMS710	83±0.311	77±0.319	72±0.322
	DMLAS-1	83±0.427	77±0.395	72±0.446

The average values of more than twelve plants (± SE).

On the vegetative stage period of *G. nivalis* development, at the prevailing negative average temperature values of the soil surface –2.53 °C, the leaves temperature averaged 1.7 times higher than the soil temperature, which indicates the ability of leaves to adapt to the influence of negative soil temperatures.

During the budding stage, due to the increase in the sunlight intensity, the soil surface layer warmed up better and, compared with the previous stage, its average temperature increased 3.3 times. The leaves temperature was 1.9 times higher, then soil temperature.

In comparison with the budding stage, during the flowering stage with an increase in the temperature of the soil surface layer by 1.8, its relative humidity decreased to 72%, while the leaves temperature increased slightly, only 1.1 times.

Probability of the connection existence between the soil temperature and the *G. nivalis* leaves temperature under natural conditions is high, which is confirmed in data sample total by the correlation coefficient value of 0.78 at $p < 0.05$. Moreover, in the vegetative stage, the bond is stronger (0.85) than during budding (0.73) and flowering (0.51) at $p < 0.04$.

Influence of relative air humidity on the leaves temperature under natural conditions during the vegetative stage, during budding and flowering, is confirmed by the corresponding correlation coefficients values 0.65, 0.87 and 0.43 at $p < 0.02$.

A direct strong relationship between the temperature of the soil surface layer near plants and the leaves temperature under natural conditions during the vegetative stage, during budding and flowering, is confirmed by the corresponding correlation coefficients of 0.95; 0.79 and 0.84 at $p < 0.02$.

Thus, during the spring development of *G. nivalis* in natural environment, at the vegetative stage at average soil temperature of –2.53 °C, the leaves showed the ability to raise the temperature to an average of +1.45 °C. During flowering, at the predominance positive soil temperatures and decrease of relative soil moisture up to 72%, the difference between the average soil temperature (+5.14 °C) and the leaves temperature (+5.78 °C) was insignificant, which is probably due to absence of stressful influence at this stage for ephemeroid plant, therefore adaptive mechanism of leaves was not activated.

Using device “DMLAS-1” in this study has shown its ability in solved problems of simultaneous automatic measurement and storage soil temperature, soil moisture, and temperature of the investigated object, in particular, the *G. nivalis* leaves, on electronic carrier. Compared to the thermograph “Fluke Ti105” and the soil moisture meter “PMS 710”, the data obtained by the “DMLAS-1” device are characterized by minor discrepancies (view Table 1), therefore the “DMLAS-1” device can used and in further scientific studies of this kind.

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