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REACTION OF EUROPEAN BEECH SEEDLING LEAVES TO HEAT SHOCK

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Summary. Heat shock is considered an abiotic stress for plant growth. The effect of heat shock of various intensity on the leaves of the seedlings of the European beech (*Fagus sylvatica* L.) was studied. The seedlings were obtained from the seeds which were collected from different regions of the Republic of Moldova, Romania and Ukraine. The magnitude of the damage dealt to the photosynthetic apparatus was determined by the method of PAM - fluorimetry. The experiment was carried out during the period when 4–5 true leaves appeared in beech seedlings at a heat shock temperature of +50 and +52°C.

Keywords: *Fagus sylvatica* L., *photosystem - 2, PAM – fluorimetry, heat resistance, heat shock.*

Introduction. Forest ecosystems are characterized by a wide variety of structures and their organization in biocenosis. Thanks to a clear hierarchy, forest plantations develop the ability to withstand the influence of environmental stress factors and gradually restore the lost dynamic balance [3]. It is believed that temperature is the main limiting factor in the growth and development of perennial woody plants [1]. Over the past decades, there has been a trend toward an increase in the average annual temperature, which is accompanied by an increase in the length of dry periods. Due to the complex structure of the crown, it is tree crops that are more closely in contact with the open atmosphere, thereby most often experiencing the effects of adverse environmental factors. This affects the state of arrays of rare and long-lived tree crops [6]. Against the background of frequent droughts caused by the action of

high temperatures, in many regions, there is a violation of the equilibrium state of ecosystems [7]. Naturally, in the course of a long evolutionary development, forest cultures have developed various mechanisms for adapting to changing environmental conditions. However, due to a sharp change in the habitat, there is a rapid death of sensitive forest species, including European beech (*Fagus silvatica* L.) [9]. This species is of great interest, both from the point of view of species conservation and the use of wood in production. In this regard, the tasks are set to solve the problems of adaptation and selection of beech genotypes with high characteristics of heat resistance for their further cultivation and restoration of sparse forest plantations [8]. To assess the reaction of tree species to the action of high temperatures and determine the state of plants, it is promising to use methods that make it possible to obtain answers to these problems in the shortest possible time and with high accuracy. Among the biophysical approaches used to analyze the state of plants, the method of PAM - fluorimetry stands out in particular. It is characterized by simplicity, expressiveness and accuracy of analyses [4]. This paper presents the results of a study of the effect of heat shock on the leaves of *Fagus sylvatica* L., assesses the degree of their damage, as well as the ability to adapt after exposure to heat shock, compares the measured chlorophyll fluorescence in the leaves of beech seedlings of various ecological origins.

Materials and methods. Beech seedlings were obtained from seeds of different growing of the Republic of Moldova, Romania and Ukraine, sown in 2020 at the experimental site of the Institute of Genetics, Physiology, and Plant Protection. When beech seedlings had 4 - 5 fully developed true leaves, PAM - fluorimetry, carried out sampling to study the assessment of primary heat resistance. The paper presents studies of 4 provenances: Hîrjauca (Moldova), Chernivtsi (Ukraine), Suceava (Romania), and Băiuţ (Romania). After sampling, the leaves were washed with distilled water, dried, and placed under stationary lighting of about 600-800 FAR for acclimatization. Before the experiment, a predetermined temperature (+50°C and 52°C) was set in a water ultra-thermostat UTF-10 (Germany), and a chamber was prepared for immersion of the selected samples. Before exposure to heat shock (HS), the fluorescence value (in terms of yield) of beech, seedling leaves was determined by a PAM-2100 fluorimeter (Germany). Heat shock was carried out at +50°C and 52°C for 5 minutes. The values of the fluorescence quantum (yield) were measured over time immediately after stress, after 15 minutes, 24, 96, and 144

hours. Each variant included 10 leaves of beech seedlings in three biological replicates. The control variant was the leaves of beech seedlings not affected by HS. The results obtained were processed in the Microsoft Excel program according to descriptive statistics [2, 5].

Results and discussions. The obtained results (Fig. 1 and 2) indicate that exposure to HS at a temperature of 50°C for 5 minutes on the leaves of beech seedlings leads to an immediate reaction of the photosynthetic apparatus (PA) of the leaf. The difference between the curves is shown in Figures. 1 and 2 indicate that the depth of induced damage to photosystem 2 (PS-2) depends on the HS temperature. As early as 24 hours after the action of HS, the difference between the reactions of leaves of different origins becomes noticeable. Before exposure to heat shock, beech leaves from different growing zones had the same yield value. After exposure to HS, the yield values fall sharply, reaching a minimum after 24 hours, and then gradually restored.

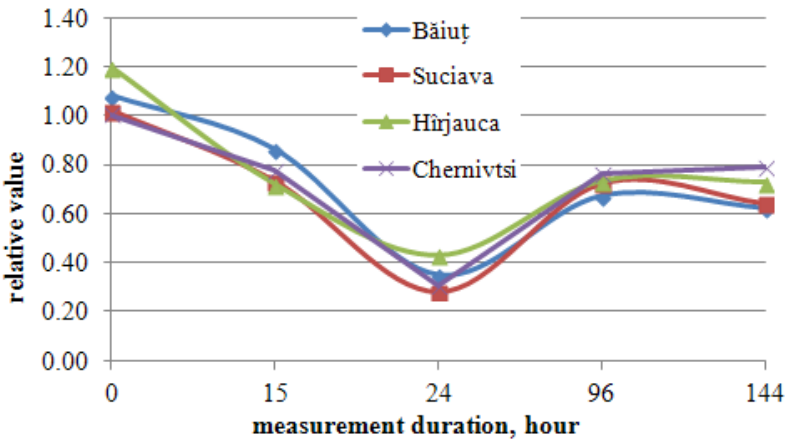


Fig.1 *Relative value of PS-2 activity after heat stress at 50°C for 5 minutes over time.*

96 hours after the action of stress, there is a sharp increase in the PS-2 yield indicator, which indicates the start of recovery processes, with the help of which gradual restoration of PS-2 activity. Note that this level of PS-2 activity is lower than the initial level and persists for at least x 48 hours. Note that a more intense restoration of PS-2 activity is observed in the variants Hîrjauca (Moldova) and Chernivtsi (Ukraine). On fig. 2, shows the results of the state of PA in beech leaves of various variants under the action of HS +52°C for 5

minutes. It should be noted that a temperature increase of only two degrees leads to significant changes in the processes of PS-2 reduction after exposure to HS. Under the action of this temperature, there is also a sharp decrease in yield, both immediately after exposure to stress and after 24 hours of recovery. At the same time, the increase in the value of PS-2 does not occur; on the contrary, the leaves of the variants Suceava (Romania) and Băiuţ (Romania) die.

Therefore, HS for 5 minutes at a temperature of +52°C is limiting for the leaves of beech seedlings, which makes it possible to make a good distinction between the resistance limit of leaves of beech genotypes of various origins. Thanks to this, it was possible to establish that the leaves of the Hirjauca (Moldova) and Chernivtsi (Ukraine) variants tend to be more resistant to HS compared to the Suceava (Romania) and Băiuţ (Romania) genotypes.

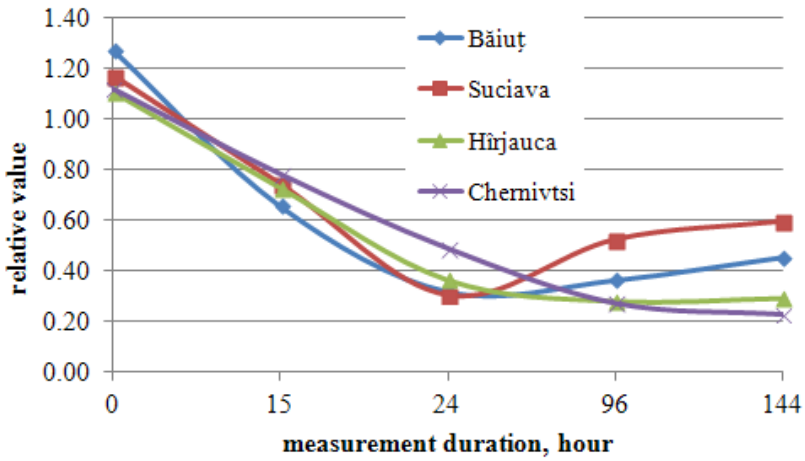


Fig.2. *The relative value of PS-2 activity after heat stress at 52°C for 5 minutes over time.*

Therefore, the influence of temperature with a difference of two degrees within 5 minutes leads to serious changes in the PA of beech leaves. As you know, the higher the degree of damage, the slower and lower the level of recovery. Our data show that after HS, the level of damage and the intensity of their recovery strongly depend on the intensity factor (HS temperature value). This indicates that the proportion of irreversible damage increases with an increase in the HS temperature. An increase in HS temperature by only 2ºC (from 50ºC to 52ºC) led to the accumulation of the proportion of irreversible damage leading to leaf death in beech genotypes from Suceava (Romania) and

Băiuţ (Romania). The ability to assess the potential of protective mechanisms, which are expressed both in quantity and in quality, makes it possible to predict the behavior of an organism under extreme conditions. Assessing the state of PA work, one can determine not only the depth of stress but also the influence of various factors on this indicator. It should be noted that the heat resistance of seedlings compared to the heat resistance of adult plants could differ significantly, which is associated with the induction of various protective mechanisms in adult plants. However, studies conducted with various biological systems indicate that the level of ontogenetic adaptations is proportional to the initial resistance. Thus, it can be expected that differences in resistance to HS in the leaves of seedlings of different beech genotypes reflect the same patterns in adult plants.

Conclusions:

- ✓ Primary resistance to HS of leaves of beech seedlings in genotypes of different origins varies.
- ✓ The use of the PAM method – fluorimetry to determine the activity of PS-2 allows you to assess the condition of beech seedlings under the influence of high temperatures during the growing season with high speed, accuracy, and minimal cost.
- ✓ The use of the PAM method – fluorimetry makes it possible to select beech seedlings that are resistant to adverse environmental factors.

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References

1. Жуков Р.С. (2012), Влияние природных экологических факторов на прирост дуба черешчатого в условиях природного заказника «Долина реки Сетунь». Лесной вестник №5/2014 с.58 – 66.
2. Использование пакета statistica 5.0 для статистической обработки опытных данных. Саратов 2001. С. 48

3. Куза П.А. (2020), Сравнительная оценка воздействия теплового шока на листья дуба черешчатого и дуба красного. Лесоведение, №3, с.231 – 238, Doi:10,31857/S0024114820030067
4. Платовский Н., Здиорук Н., Раля Т. (2020), Применение метода флуориметрии для оценки первичной теплоустойчивости флаговых листьев гексаплоидной пшеницы в зависимости от температуры теплового шока. Известия Академии Наук Молдовы №2(341), с. 67 – 72. ISSN 1857 -064X
5. Рязанова Л. Г., Проворченко А. В., Горбунов И. В. (2013), Основы статистического анализа результатов исследований. Краснодар с. 61
6. Уткина И.А., Рубцов В.В. (2017), Устойчивость фенологических форм дуба черешчатого к неблагоприятным внешним факторам. Известия Санкт-Петербургской лесотехнической академии. Вып. 220 с. 200 – 210
7. Hanson, P.J., Weltzin, J.F., (2000), Drought disturbance from climate change: response of United States forests. Set. Total Environ. 262: 205 – 220
8. Jose C.M., Chiara c., Cocozza C., Lassere B., Tognetti R. and Georg von Arx (2022). Wood anatomical response of European beech to elevation, Land use change, and climate variability in the central appeninas, Italy. Frontiers in plant science, March 23, Volume 13, Article 855741, p. 1 – 18. DOI:10.3389/fpls.2022.855741
9. Walther, L., Ganthaler, A., Mayr, S., Saurer, M., Waldner, p., Walser, M., et. al., (2021) from the comfort zone to crown dieback sequence of physiological stress threshold in mature European beech trees across progressive drought. Sci. Total Environ. 753:141792. DOI:10.1016/j.scitotenv.2020.141792