SECTION 2. EXPERIMENTAL BOTANY

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THE PROBLEM OF DROUGHT TOLERANCE AND WATER POTENTIAL AS AN INDICATOR OF OSMOTIC RESISTANCE OF PLANTS UNDER THE INFLUENCE OF HEAVY METALS

ПРОБЛЕМА ПОСУХОСТІЙКОСТІ ТА ВОДНОГО ПОТЕНЦІАЛУ ЯК ПОКАЗНИК ОСМОСТІЙКОСТІ РОСЛИН ПІД ДІЄЮ ВАЖКИХ МЕТАЛІВ

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Global climate change and the acute shortage of fresh water, even for drinking, are hindering the cultivation of valuable crops. Drought is one of the most common adverse abiotic environmental factors that plants face during ontogeny. According to various estimates, areas with an arid climate occupy from 45% of the land area [1, p. 22]. Water deficit in plants occurs when the water supply to the roots is impaired, when the transpiration rate is high, when high and low temperatures are applied, when plants are damaged by pests, diseases, excessive insolation, and salinity. Drought is also a critical factor in the processes of growth and development, as well as a decrease in water potential [2, p. 73].

Therefore, water deficit is considered a type of osmotic stress; therefore, water status studies are conducted from this perspective. In vitro studies of water stress indicate that dehydration is the primary cause of a significant limitation of the body's vital functions.

It is known that abiotic stresses cause a complex of interrelated reactions that can occur simultaneously or alternately. If the modelling stress agent is a substance that is highly toxic in relatively small quantities and therefore causes significant cellular damage, cell selection can become the main method of obtaining plant forms with unique characteristics. Such characteristics are associated with heavy metal ions (HMI), especially the group of HMI that are toxic in residual amounts and are considered physiologically unnecessary. Such HMIs include: Ba^{2+}, Cd^{2+}, Hg^{2+}, Pb^{2+} [3, p. 80; 4, p. 111887].

The Cd^{2+} ion was used to create an in vitro model system. The selective concentration for the ion was determined in previous experiments. It was considered to be the smallest amount of stressor that stopped the development of the wild-type cell culture. The test was performed using tobacco (*Nicotiana tabacum* L.) cell cultures.

In accordance with the developed scheme and rules of cell selection, each stage of the experiment was accompanied by constant monitoring. The relative biomass growth rate (Δm) was constantly monitored to determine the stability.

It is known that the water balance in plants can be maintained by a special class of proteins – dehydrins. This class includes LEA (late embryogenesis abundant proteins), proteins of the late stage of embryogenesis. A number of publications have noted that Cd^{2+} ions have a negative effect on LEA [5, p. 320]. Therefore, Cd^{2+} was used to obtain tobacco cultivars resistant to water stress. Our idea is based on the nature of the effect of Cd^{2+} ions on the water status of the plant. Cd^{2+} ions significantly inhibit the activity of LEA, one of the groups of dehydrin proteins. These proteins are directly related to the maintenance of the plant's water balance by moving water inside the body and transporting it between individual tissues. Therefore, we assume that cell lines resistant to a lethal dose of Cd^{2+} will have an increased level of resistance to the modelled stress.

A variation of osmotic stress is water stress, during which the plant organism is exposed to only the osmotic component and suffers dehydration. Mannitol was used as a stress factor, which had previously confirmed its effectiveness [6, p. 16].

Under conditions of permanent water stress, irreversible dehydration of plant cells occurred. Plant resistance is ensured not only by the integrity of the outer membranes, but also, and no less importantly, by the strength of the membranes of cellular organelles. For example, it has been shown that late embryogenesis-associated proteins (LEAM) located in mitochondria protect the inner membranes of these organelles from dehydration.

When considering the issue of membrane permeability under osmotic stress, it is always necessary to keep in mind the nature of this phenomenon. If the change in membrane permeability is temporary and reversible, then it can be considered a nonspecific adaptive syndrome. Membrane permeability was assessed by K^+ leakage. It is known that K^+ can leak both reversibly and irreversibly. In the first case, K^+ leakage is carried out through plasma membrane potassium channels. The role of K^+ channels is the rapid release of K^+ in response to a damaging effect [7, p. 375]. In a cell, the activity of more than 60 enzymes depends on the presence of K^+ ions. The leakage of the latter blocks the activity and thus reduces the metabolic rate. Endogenous inhibition of metabolism under the influence of adverse factors weakens the effect of damage, which, in turn, creates conditions for more effective repair. In this way, the reaction of metabolic inhibition performs a nonspecific protective function [8, p. 733]. In our experiments, it is possible that cells with altered membrane properties proliferate as a result of primary selection on media with HMI. If we compare the K^+/Na^+ ratio under osmotic stress in cell cultures and regenerants obtained from them, we can see a complete analogy. Under the influence of simulated salinity, significant amounts of Na^+ ions accumulate in cells (callus and plant) [9, p. 1663].

Cell lines selected on selective media with HMI are characterised by resistance to osmotic stress. Cd-RCLs respond to changes in the osmotic pressure of the external environment. The Cd-RCL selected on media with lethal doses of HMI are characterised by complex resistance to osmotic stress. Complex resistance is realised in the form of adaptation to a specific stress factor.

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