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PLANT HORMONS ABSCISIC AND INDOLE-3-ACETIC ACIDS IN WINTER WHEAT UNDER HEAT STRESS AND AFTER RECOVERY: DYNAMICS AND DISTRIBUTION

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The study of the climatic changes impact of on the productivity of cultivated plants is one of the urgent issues of modern biological science. One of the main reasons for the increased interest in this problem is the marked change in the intensity and frequency of many climatic phenomena in recent years: significant variation in daily temperatures, rainfall, etc [1, p. 13].

Plant growth and development is regulated by a complex hormonal system, the interaction between components of which is either synergistic or antagonistic. Phytohormones are considered to be the most important endogenous substances modulating physiological and molecular responses in plants surviving under stress conditions. Abscisic acid (ABA) is regarded as an effective regulator of stress responses, the activity of which is determined by the concentration and localization in the cells, tissues and organs of the plant [2, p. 27-41]. The accumulation of endogenous ABA and the subsequent inhibition of growth are regarded as an adaptive response aimed at maintaining the plant's viability in adverse conditions and subsequent recovery after the cessation of stress [3, p. 373-386]. Hormone-induced closure of stomata occurs seconds to minutes following the onset of the stressor effects [4, ra32]. The hormone also controls the uptake and transport of water by the root system [5, p. 1321-1358]. Indole-3-acetic acid (IAA) is involved in the regulation of division, elongation and differentiation of cells, photo– and gravitropisms, apical dominance, embryo-, organs– and morphogenesis, development of the root system [6, p. 1757-1773]. As a result of abiotic stress effects, IAA homeostasis is disturbed, which adversely affects plant growth and development [7, p. 965-975].

Wheat is one of the major agricultural crops in Ukraine and the world. Studying the mechanisms of stress resistance formation in this culture is extremely important for breeding studies aimed at selection of new genotypes. Since ABA and IAA are characterized by different nature of action on growth processes and at the same time are active components of stress resistance, the aim of our work was to investigate the dynamics and balance of these hormones in the organs of young winter wheat plants under simulated short-term hyperthermia and after recovery.

The study was conducted on the winter wheat (*Triticum aestivum* L.) cv. Podolyanka, which belongs to the group of strong high-yielding wheat, with frost– and drought-resistance. Wheat grains were obtained from the collection of the Institute of Plant Physiology and Genetics, NAS of Ukraine. Calibrated grains were germinated in a thermostat at +24°C for 21 h, planted in vessels with calcined river sand. Plants were grown under controlled conditions at +20/17°C (day/night), light intensity 690 μmol/(m2 s), photoperiod 16/8 h (day/night), relative humidity 65±5%. To simulate temperature stress, 14-day-old plants (2 leaf phase) were placed in a thermostat at + 40°C for 2 h. Hormone content was measured before and after heat stress (14th day) and after plant recovery (21st day). Phytohormones were analytically quantified using HPLC-MS on an Agilent 1200 LC liquid chromatograph with a G 1315 V diode-matrix detector (USA) in tandem with an Agilent G6120A single-quadrupole mass spectrometer [8, p. 14-25]. The experiments were performed in three biological and three analytical replicates. For each biological replicate, 40 plants were selected. Data analysis was performed using Microsoft Excel. Difference between cases and controls was evaluated using Student's t-test, and tests deemed statistically significant if $p \leq 0{,}05$ were obtained.

Morphological parameters of growth under stress factors are integral characteristics of the plant physiological state. Previously, we showed that, in the case of short-term hyperthermia, the root mass of 14-day-old winter wheat plants increased by 33%, but on the 21st day, complete morphological recovery did not occur [9, p. 324-337]. We found that during the growth and development of winter wheat plants there was an active accumulation of endogenous phytohormones. Thus, the content of ABA in shoots of 21-day plants compared with 14-day plants increased by 71,4%, and in the roots by 19,9%, while the amount of IAA in shoots increased by 20,2%, and in the roots by 1,9%. Thus, in the early stages of ontogeny, intense accumulation of phytohormones occurred in shoots of winter wheat. We showed that heat stress caused an increase in the content of endogenous ABA in shoots and roots of the studied plants by a factor of 1,3. The concentration of the hormone reached 39,5±2,0 and 19,0±0,9 ng/g of fresh weight, respectively. At the same time, the content of endogenous IAA decreased 2,1-fold in roots and 1,7-fold in shoots, reaching 51,7±2,6 and 44,4±2,2 ng/g of fresh weight, respectively. During the recovery period on the 21st day, a further accumulation of endogenous ABA was observed. The content of the hormone in shoots increased 1,3-fold, and in the roots – 2,1-fold. The endogenous IAA content increase by 80,4% during the recovery period occurred mainly in shoots, whereas in the roots only by 8,7%. However, the measurements in the experimental plants were below control values. During the recovery period IAA accumulated predominantly in shoots.

Plasticity of plants, their ability to adapt to stressful conditions is mediated by a network of phytohormonal signaling cascades [10, p. 49-67]. We showed that after short-term hyperthermia in winter wheat the content of ABA increased, while that of IAA – decreased. ABA along with other hormones is involved in control of communication between the root and the plant stem, regulates the transport of water and salts. Stress-induced accumulation of ABA, as one of the mechanisms of metabolism slowdown, allows plants to adapt [11, p. 161]. The lowest amounts of IAA were found in the roots of young plants. Further accumulation of ABA, predominantly in shoots, was observed during the recovery period, with the hormone content of the recovering plants higher than that of controls. The IAA level in the recovery period also increased mainly in shoots, but did not reach control levels. Some studies have indicated that crosstalk between ABA and IAA signaling pathways modulates plant growth and survival under stress conditions [12, p. 475-488]. Our results suggest that the dynamics of growth processes under the action of hyperthermia and during the recovery period is governed by changes in the balance and localization of ABA and IAA in organs of wheat.

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