

THE EFFECT OF IONIZING RADIATION ON THE STABILITY OF PHYTOCENOSIS IN CONDITIONS OF GLOBAL WARMING

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Abstract. This study examines the role of anthropogenic load in shaping plant surface temperature under high and extreme thermal conditions. Gamma irradiation was applied as a universal damaging factor. Field experiments showed that under normal temperatures, the difference between control (non-irradiated) and irradiated plants did not exceed 2–3 °C, while under elevated and extreme temperatures, it increased to 100 °C. Laboratory analyses of transpiration intensity confirmed that radiation is a major factor reducing the transpiration potential of irradiated plants. These findings highlight the relevance of plant resistance under global warming and emphasize the need to minimize anthropogenic impacts on phytocenoses to enhance their resilience to rising temperatures associated with climate change.

Key words: radiation, phytocenoses, plant radioresistance, transpiration

Global warming, more formally referred to as global climate change, is understood as fluctuations in the Earth's climate system occurring worldwide or within specific regions, expressed in statistically significant deviations of weather parameters from long-term averages over periods ranging from decades to millions of years. According to the United Nations, this phenomenon reflects long-term shifts in temperature and weather conditions, driven by both natural processes and anthropogenic influences. Among the multiple manifestations of climate change, one of the most critical consequences is the suppression of vegetation and the degradation of phytocenoses. Increasing frequency and intensity of extreme weather events subject plants to droughts, floods, hurricanes, and forest fires, resulting in physical damage, mortality, or decreased agricultural yields [1–4]. Another important factor is habitat alteration [5]; rising temperatures force plant species to migrate toward cooler regions or higher elevations, yet many cannot adapt quickly enough, leading to population decline or extinction. Regional changes in precipitation further exacerbate ecological stress. While some regions are experiencing increased rainfall, others are facing progressive aridification, often causing desiccation and large-scale mortality of plant communities. A further consequence of climate change is the disruption of phenological cycles [6]. Shifts in key processes such as flowering, fruiting, and leaf fall, when combined with anthropogenic stressors, may accelerate the degradation of entire phytocenoses. At the same time, generalizing results and interpreting model studies that employ various physicochemical factors presents certain challenges, as different mechanisms of negative impact may act simultaneously on the objects under study.

To study phytocenological stability, we used plants irradiated with gamma radiation. Ionizing radiation was selected because, according to its mechanism of action, it can be considered a *universal damaging factor* for plant communities.

The experimental material consisted of sunflower (*Helianthus annuus*) and soybean (*Glycine max*) sprouts and seeds. Radiation treatment was performed using the gamma installations GUPOS-3M and Gamma-capsula-2, with ¹³⁷Cs as the radiation source. The dose rate during irradiation was 1.1 Gy/min, and all procedures were carried out at a temperature of 25 ± 2 °C. A dose range of up to 150 Gy was applied. After irradiation, both experimental and control (non-irradiated) materials were planted in open ground within 3–5 days, following all standard agrobiological practices. Temperature changes in control and irradiated plants were monitored using laser surface scanning.

No significant differences in leaf surface temperature were observed between control and irradiated plants throughout most of the growing season, with differences not exceeding 2–3 °C. At atmospheric temperatures up to 30 °C, the maximum surface temperature of control plants did not exceed 27–28 °C, while plants irradiated at 100–150 Gy displayed similar values. However, under extremely high temperatures (39–43 °C), the difference became pronounced: irradiated plants exceeded the control group by up to 10–12 °C. Specifically, while the control group varied within 30–32 °C, irradiated plants at doses of 100–150 Gy reached 40–43 °C (Fig. 1).

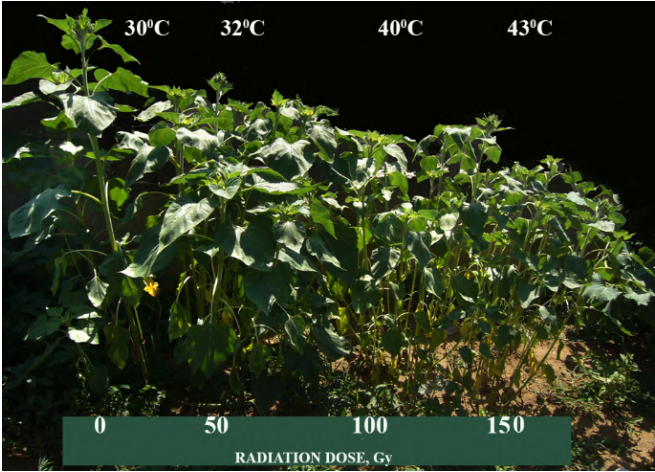


Fig. 1. Effects of radiation on growth, development, and surface heating of plants under conditions of extreme temperature increase

The observed increase in leaf surface temperature in irradiated plants can be attributed to a significant disruption of the transpiration process. This effect may result from both reduced surface evaporation and limited soil moisture availability. However, since all plants in our experiment were grown under identical field conditions, the primary cause is most likely a decrease in leaf transpiration. To investigate the dose dependence of moisture evaporation from the leaf surface, we analyzed the dynamics of the daily transpiration coefficient. In contrast to the sunflower experiment, which involved pre-sowing seed irradiation followed by open-field cultivation, transpiration activity was assessed in soybean sprouts under controlled laboratory conditions. Considering the different radioresistance of seeds and sprouts, the experiments were performed with a dose range not exceeding 20 Gy. Fig.2 presents the dose–response curve of transpiration intensity, calculated from daily surface water evaporation. As shown, the trend of the dose curve closely corresponds to the field observations of leaf surface heating under elevated temperature conditions.

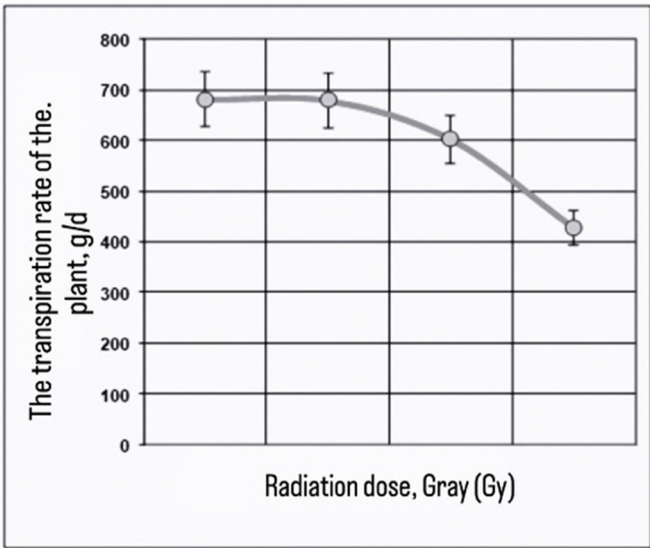


Fig. 2. Effect of gamma radiation on transpiration rate in seedlings

Summarizing the obtained data, it can be concluded that when plants are exposed to various physical and chemical stress factors under elevated or extreme temperatures, the protective system preventing leaf surface overheating is disrupted.

In general, global warming exerts a profound impact on plants and ecosystems, necessitating strategies both to mitigate its consequences and to facilitate adaptation to new conditions. Climate change and the associated temperature stress affect plants in multiple ways, one of which is the alteration of plant community composition. Shifts in interspecific competition may promote the dominance of species more resistant to high temperatures or drought, while less tolerant species are displaced. Such processes can significantly transform characteristic landscapes and, in some cases, result in irreversible ecological damage.

The reduction in transpiration levels demonstrated in our study highlights a critical mechanism of plant vulnerability, which under prolonged stress may progress to severe physiological damage or even complete plant death. Therefore, to mitigate the negative consequences of global climate change, it is essential to develop measures aimed at reducing anthropogenic pressure on phytocenoses, thereby enhancing their natural resistance to extreme thermal conditions.

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