EVALUATION OF THE TOLERANCE OF *SESAMUM INDICUM* L. SAMPLES TO WATER STRESS UNDER CONTROLLED EXPERIMENTAL CONDITIONS

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ABSTRACT
Water stress is one of the major abiotic factors limiting the growth and productivity of agricultural crops, including *Sesamum indicum L.* The aim of this study was to evaluate the tolerance of sesame samples to water stress under controlled experimental conditions at early stages of development. The study included 15 samples obtained through X-ray induced mutagenesis from the genotypes *Zaltsadovski, Kadet* and *Adaptovanîi 2*, as well as the initial genotypes used as controls. Water stress was artificially simulated using a 15% PEG 6000 solution. Tolerance was assessed based on seed germination and seedling morphometric parameters. The results revealed significant differences among genotypes and irradiation treatments, with the most tolerant samples identified in the variants *Zaltsadovski* – 200 Gy, *Kadet* – 50 Gy and *Adaptovanîi 2* – 200 Gy. The results confirm the usefulness of induced mutagenesis for identifying sesame forms with increased tolerance to water deficit.
Keywords: *Sesamum indicum*, water stress, induced mutagenesis, PEG 6000

1. INTRODUCTION

Water stress is a major abiotic factor limiting crop growth, development, and productivity worldwide. Increasing drought frequency due to global climate change reduces agricultural yields and highlights the need to identify genotypes adapted to water-deficit conditions [4, 8]. In this context, investigating the physiological, biochemical, and molecular mechanisms underlying plant responses to water stress remains a key priority in modern agricultural research [1, 2, 3].

Sesamum indicum L. (sesame) is a valuable oilseed crop, appreciated for its high oil content and bioactive compounds of nutritional and medicinal importance. It is mainly cultivated in semi-arid and arid regions, where drought is the principal factor limiting production [5]. Although sesame is relatively drought-tolerant compared with many crops, severe water deficit can markedly reduce seed yield and quality [1]. For controlled evaluation of drought tolerance, water stress is often simulated using polyethylene glycol (PEG) solutions. This method reduces osmotic potential and provides uniform conditions for comparing genotypic responses during germination and early growth. Commonly assessed traits include germination percentage and rate, radicle and shoot length, vigor index, biomass, and relative water content [6, 7]. Tolerance to water stress is a complex polygenic trait strongly influenced by genotype × environment interactions. Recent studies emphasize the role of antioxidant defense mechanisms and the accumulation of osmolytes, such as proline and soluble sugars, in maintaining osmotic balance and protecting cellular structures under water-deficit conditions [1, 10]. Evaluation of drought-tolerance indices based on agromorphological and physiological traits also supports the identification of superior genotypes for breeding programs [3, 9].

In addition, induced mutagenesis and analysis of segregating generations help expand genetic variability and enable selection of stable lines with high adaptive potential [6]. Initial results on drought-tolerant *Sesamum indicum* mutants at early developmental stages confirm the effectiveness of this approach.

Overall, investigating water-stress tolerance in *Sesamum indicum* through modern artificial simulation methods and evaluation of morphophysiological traits is essential for developing drought-adapted varieties. Open-access scientific resources further strengthen the theoretical and applied basis needed to support breeding programs focused on maintaining yield stability under climate change conditions [3,11].

2. MATERIALS AND METHODS

To evaluate drought stress tolerance at the early developmental stage, 15 sesame (*Sesamum indicum* L.) samples obtained through X-ray–induced mutagenesis from the genotypes *Zaltsadovski, Kadet*, and *Adaptovanîi 2*, as well as their original genotypes used as controls, were investigated. The seeds were irradiated with doses of 50, 200, 400, and 500 Gy and cultivated in the M_1 generation. The plant material was obtained from the experimental field of the Institute of Genetics, Physiology and Plant Protection of MSU.

The assessment of drought stress tolerance was performed by artificial simulation of water deficit using a 15% polyethylene glycol (PEG 6000) solution, corresponding to an osmotic potential of 0.295 MPa. For each experimental variant, 50 seeds were placed in 90 mm Petri dishes on two layers of filter paper. Two treatments were applied: control (10 ml distilled water) and osmotic stress (10 ml of 15% PEG 6000 solution). The Petri dishes were incubated in darkness at 28°C for 5 days, and the experiment was repeated three times for each variant.

After the incubation period, the number of germinated seeds (G), root length (RL), and shoot length (SL) (mm) were recorded under both control and stress conditions [2].

Drought stress response was evaluated using a Water Stress Response Index (WSRI), which represents an integrative measure of the ability to maintain germination and growth under water deficit conditions. WSRI expresses, in percentage terms, the capacity of genotypes to sustain biological performance under stress and is calculated according to the following equation:

$$\mathrm{WSRI}(\%) = \frac{1}{3}\left(\frac{G_s}{G_m}\,x\,100 + \frac{RL_s}{RL_m}\,x\,100 + \frac{SL_s}{SL_m}\,x\,100\right)$$

where:

G_s, RL_s, SL_s represent germination, root length, and shoot length under osmotic stress conditions;

G_m, RL_m, SL_m represent the corresponding values under control conditions.

As evaluation indicators, germination, root length, and shoot length were analyzed as parameters of growth and development at the early ontogenetic stage.

3. RESULTS AND DISCUSSION

Analysis of variation in the water stress response index (WSRI) of sesame samples obtained through X-ray-induced mutagenesis revealed significant differences among genotypes and irradiation doses. Lower WSRI values indicate greater tolerance to water stress, whereas higher values reflect increased sensitivity to water deficit and differences in phenotypic plasticity.

In the control treatment, seed germination of the studied *Sesamum indicum* samples ranged from 84 to 100%, confirming good suitability for testing. Under osmotic stress induced by PEG 6000, germination decreased to 20–76%.

In the case of samples derived from the *Zaltsadovski* genotype (Figure 1), a pronounced variability of index values is observed depending on the applied irradiation dose. The control variant shows an intermediate level of the index, reflecting the natural response of the genotype to osmotic stress conditions. The application of a 200 Gy dose resulted in the lowest index value, indicating a better capacity to adapt to water stress and, consequently, a higher tolerance of this sample during the early stages of development.

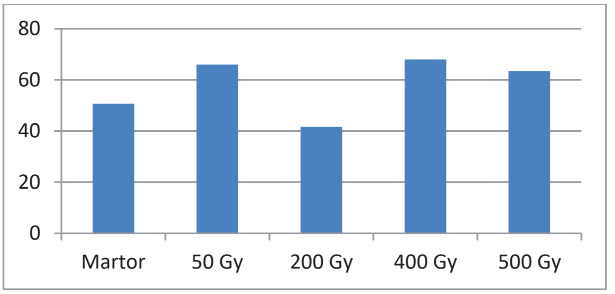

Figure 1. Variation of the water stress response index (%) in sesame samples derived from the Zaltsadovski genotype, depending on the X-ray irradiation dose, during the early stages of development

In contrast, at doses of 50 Gy, 400 Gy, and 500 Gy, higher index values are recorded, suggesting increased sensitivity to water stress, characteristic of genotypes with more pronounced phenotypic plasticity. This variability highlights that induced mutagenesis can generate both forms with enhanced adaptive potential and forms that are more sensitive to water-deficit conditions.

The obtained results are also confirmed by the analysis of seedling morphometric parameters. Thus, regarding root length, in the *Zaltsadovski* – 200 Gy variant, the smallest reduction under osmotic pressure is recorded, with a value of 11.05 mm, compared to the control variant, where root length reached 26.62 mm. A similar trend is observed for shoot length, where the 200 Gy variant shows a value of 12.45 mm, compared to 36.88 mm in the control, confirming a higher stability of growth processes under water stress conditions.

For the samples derived from the *Kadet* genotype (Figure 2), the dynamics of index values indicate a relatively stable response to water stress, but with clear differences among experimental variants. The lowest index value is recorded at the 50 Gy dose, indicating higher tolerance to osmotic stress compared to the control. At doses of 200 Gy, 400 Gy, and 500 Gy, higher index values are observed, suggesting relatively greater sensitivity to water deficit. At the same time, the gradual increase in index values at these doses may reflect more pronounced phenotypic plasticity, expressed through changes in germination rate and seedling growth under stress conditions.

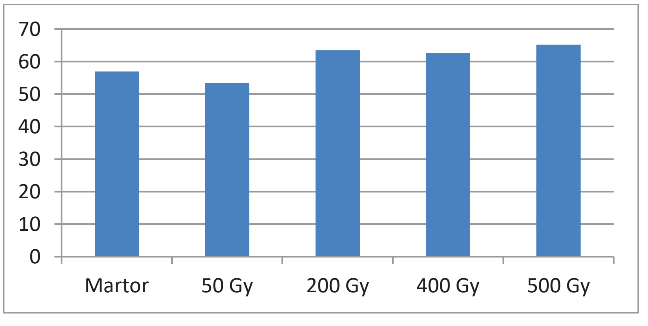

Figure 2. Variation of the water stress response index (%) in sesame samples derived from the Kadet genotype, depending on the X-ray irradiation dose, during the early stages of development

The analysis of growth parameters confirms these trends. Thus, in terms of root length, the smallest difference under osmotic pressure is recorded in the *Kadet* genotype – control, where root length is 11.60 mm, compared to the untreated control variant, where it reached 30.70 mm. A similar situation is observed for shoot length, where the recorded value is 11.75 mm, compared to 33.30 mm in the untreated control variant.

In the case of the *Adaptovanîi 2* genotype (Figure 3), the response of the samples to water stress shows a different pattern compared to the other analyzed genotypes. The 200 Gy dose results in the lowest index value, indicating increased tolerance to water-deficit conditions during the early stages of development. In contrast, the 50 Gy dose leads to the highest index value, suggesting pronounced sensitivity to water stress and reduced plasticity in terms of adaptation to osmotic stress conditions. The values recorded at 400 Gy and 500 Gy are intermediate, indicating a moderate response to stress and suggesting the presence of forms with a medium level of adaptability.

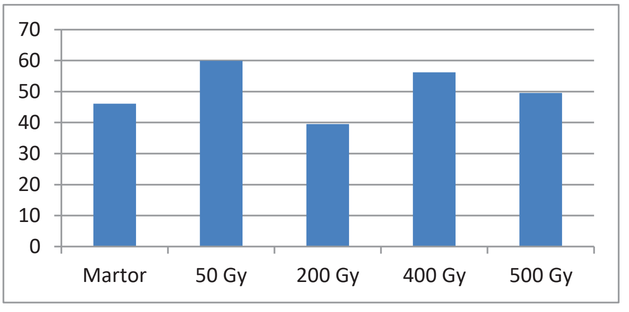

Figure 3. Variation of the water stress response index (%) in sesame samples derived from the Adaptovanîi 2 genotype, depending on the X-ray irradiation dose, during the early stages of development

The results are also supported by the analysis of morphometric parameters. Thus, in terms of root length, the *Adaptovanîi 2* – 200 Gy genotype shows the smallest difference under osmotic stress, with a value of 17.17 mm, compared to the control variant, where root length was 29.31 mm. A similar trend is observed for shoot length, where the 200 Gy variant records a value of 12.00 mm, compared to 36.93 mm in the control.

The comparative analysis of results for the three genotypes demonstrates that the response to water stress depends both on the genetic background of the initial genotype and on the intensity of the applied mutagenic factor. In general, intermediate irradiation doses favored the emergence of samples with lower values of the stress response index, indicating higher tolerance to water deficit. At the same time, higher index values reflect genotype sensitivity and differing levels of phenotypic plasticity, which may be explained by genetic modifications induced by ionizing radiation.

4. CONCLUSIONS

1. The testing of sesame samples obtained through X-ray-induced mutagenesis revealed significant variability in the response to water stress during the early stages of development, determined both by the genetic background of the genotypes and by the applied irradiation doses.
2. The artificial simulation of water stress using PEG 6000 (15%) resulted in a considerable reduction in seed germination (from 84–100% to 20–76%), confirming the effectiveness of the method for evaluating tolerance to water deficit.

3. The most tolerant samples were identified in the variants *Zaltsadovski* – 200 Gy, *Kadet* – 50 Gy, and *Adaptovanîi 2* – 200 Gy, which showed lower values of the stress response index and smaller differences in growth parameters under osmotic pressure conditions.
4. The obtained results confirm that X-ray-induced mutagenesis can generate sesame forms with enhanced adaptive potential to water stress, representing valuable material for breeding programs aimed at developing drought-tolerant varieties.

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DECLARATION
Originality Statement: The authors confirm that this manuscript is original, has not been published previously, and is not under consideration elsewhere.
Data Availability Statement: The datasets generated during the current study are available from the corresponding author upon reasonable request.

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