Effect of abiotic stresses on the physiological characteristics of rice (*Oryza sativa*)

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Abstract. This article conducts an analysis of water balance indicators for the "Lazurniy" and "Sadaf" rice varieties. Through this analysis, the study aims to uncover insights into the water requirements and responses of these two rice varieties. The research findings reveal distinct characteristics of each variety in terms of their water usage and yield performance. The analysis underscores that the "Lazurniy" variety falls within the category of intensive type varieties. This designation is associated with its ability to thrive and deliver high yields in environments characterized by abundant agricultural resources. On the other hand, the "Sadaf" variety exhibits a different trait - it showcases relative resistance to water shortage stress. This resilience suggests that the "Sadaf" variety has the capacity to maintain its performance even under conditions of limited water availability. By delineating these variations in water balance indicators, the research contributes to a deeper understanding of the adaptability and yield potential of both "Lazurniy" and "Sadaf" rice varieties. This information holds relevance for crop selection and management decisions, allowing growers to make informed choices based on the specific agro-environmental conditions they face. Ultimately, this analysis contributes to the optimization of rice cultivation practices by aligning crop varieties with their respective water requirements and stress tolerances.
Keywords. Rice, transpiration, water storage capacity, leaf dry weight.

1 Introduction

Due to the accelerated climate change process and population growth in recent years, water availability is a critical issue for agriculture, which is the world's largest water consumer, accounting for more than 70% of global water consumption. Irrigated agricultural crops cover 20% of the world's cultivated land and account for 40% of the world's food production. Irrigated agricultural crops produce at least twice the yield per unit of land compared to dryland [1]. Water usually contains 50-90% of a plant cell. Most of the water content (60-90%) is inside the cells, and the rest is mainly located in the cell walls [2]. Maintaining growth and productivity under unfavorable environmental stress conditions such as water scarcity is one of the main challenges in modern agriculture, including rice cultivation [3].

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Nowadays, global climate change is causing various natural disasters. Floods caused on by environmental factors reduced the production of 22 million hectares of rice-planted regions worldwide, including the rice crop. Half of them are in eastern India [4].

Although the rice plant requires a large amount of water for normal growth and development, excess water supply harms productivity. This is due to the fact that different submerged plant tissues have a difficult time transferring oxygen [5], which generates an adverse environment for the plant and results in an oxygen deficit state ($O_2 < 21\%$) [6]. When water deficit stress occurs, cell membrane signaling processes are activated, thereby resisting the stress through physiological processes and the positive function of responsive genes. In this context, many mechanisms, photosynthesis and gas exchange [7, 8], cell degradation, changes in cell membrane composition [9], translocation of nutrients [10], transcriptional activity of genes, transposable elements [11], lipid signaling [12], metabolites, proteins [13] and antioxidants [14] can be altered under stress.

The above-mentioned imbalances that occur under water deficit stress direct the plant energy and nutrients to protective processes, resulting in a decrease in growth, development, generative organs and biomass formation.

The effect of soil drought stress during water deficit is the occurrence of an antioxidant defense system and disruption of reactive oxygen species (ROS) protection processes [15]. In addition, changes at the molecular level are responsible for the synthesis of proteins related to stress tolerance, such as stress-sensitive expressed genes, enzymes ascorbate peroxidase (APX), and high-temperature resistance proteins (HSP) [16].

2 Materials and methods

Our research was conducted in the field of the experimental farm of the Rice Research Institute. "Sadaf" and "Lazurniy" varieties were used as experimental material. Physiological indicators of water balance during the growing season of rice varieties were evaluated - the water content of the flag leaf, transpiration rate, water retention character, and dry weight of the leaf. In order to determine the total water content of plant leaves and the water retention properties of leaves, 5 leaves were taken from each option and weighed on an electronic scale, and placed under room conditions.

After 2 hours of exposure, their weight was measured again. Then dried in a drying cabinet at 100-105 °C for 3 days, the dry weight of the leaves was measured, and through this way, the total water content in the leaves and the water holding properties of the leaves were determined. Data obtained were analyzed statistically using ANOVA software (www.statview.com) [17]. According to L.A. Ivanov's approach [18] and A.A. Nichiporovich's research on the water retention capacity of leaves, transpiration activity was measured.

3 Results and discussion

In conditions of the optimal water supply of the plant, the high total water content in the leaves causes the formation of generative and vegetative organs at an optimal level. When the total water content of the flag leaf was studied among the rice cultivars, it was observed that there was no statistically significant difference. However, during water scarcity, the plant's minimal water reserve has a substantial impact on metabolism. In the results of the analysis, the highest indicator was observed in the variety "Sadaf" and the total water content was 94.3%. Accordingly, there was no significant difference in the "Lazurniy" variety, which was 94.2%. It is known that the optimal level of water supply in leaves ensures normal metabolic processes in it (Figure 1).

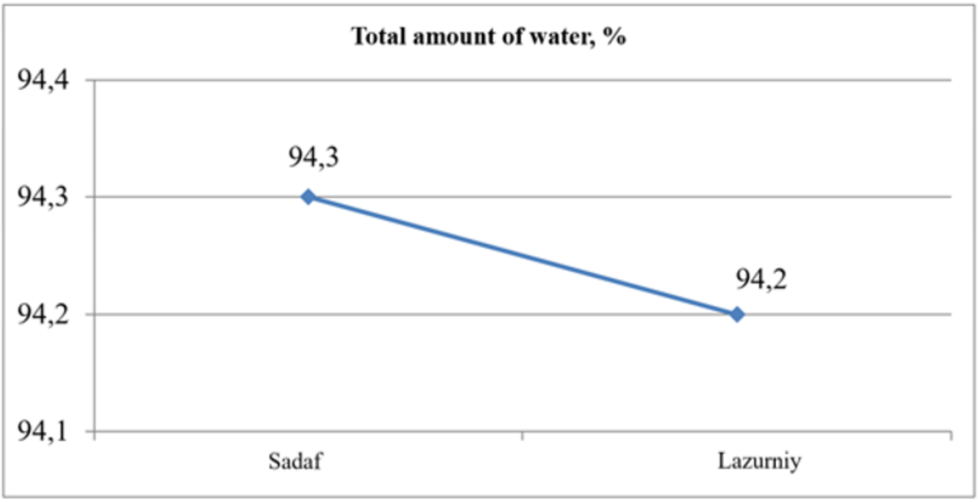

Figure 1. Total amount of water, %.

One of the key physiological factors, transpiration plays a crucial role in plants' water exchange. Transpiration is one of the main processes in plant water balance management. Transpiration rate is the content of water evaporated from a plant leaf in 1 hour (H_2O/1g wet leaf x 1 hour). In our experiments, it was found that there is a relative difference between varieties in terms of transpiration rate, while the "Sadaf" variety was 398.5 mg, and the "Lazurniy" variety was 335.5 mg. It is known that the decrease in the rate of transpiration in plants during water shortage is due to the decrease in the total water content and free water content of plant leaves, loss of turgor, and wilting of leaves (Figure 2).

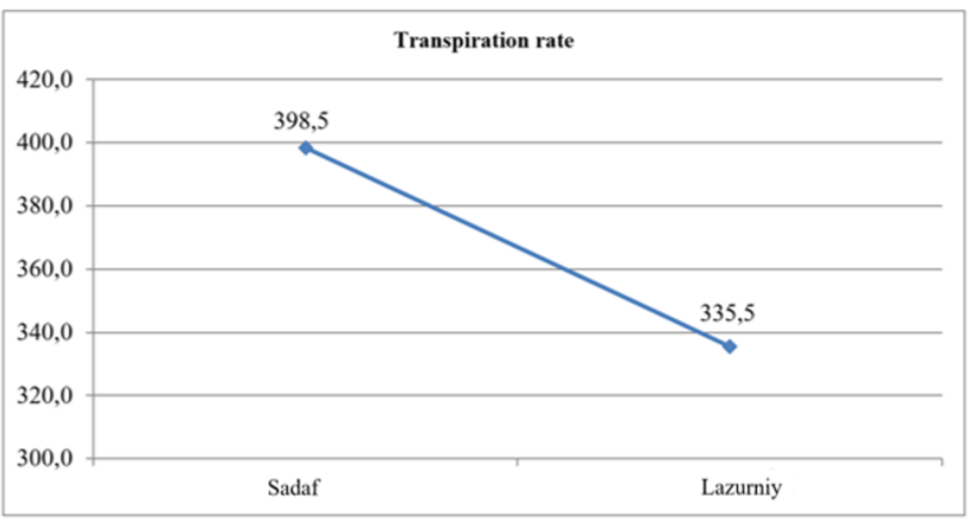

Figure 2. Transpiration rate.

The next indicator in our analysis results is the water retention property of the plant, which depends on various factors, soil moisture, and morphological, anatomical, biological, and genetic characteristics of the plant. Water retention refers to the percentage of water lost after two hours compared to the initial water content of the leaves. Therefore, a low index means a high water retention property of the leaf (Figure 3).

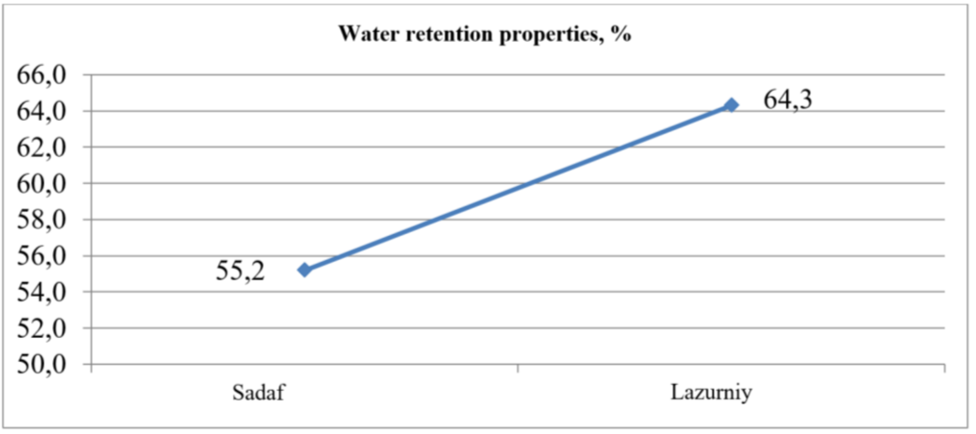

Figure 3. High water retention property.

In our analysis, it was noted that the water retention property of rice varieties is 64.3% in the "Lazurniy" variety, which is relatively low, and on the contrary, it is 55.2% in the "Sadaf" variety, which is high. The reason for the high total water content and transpiration speed of the "Sadaf" variety can be explained by the well-developed root system and the ability to adapt to the stress conditions of the external environment. In addition, the variety "Sadaf" is distinguished by the fact that the leaf surface is large. In our research, the increase in the water retention properties of the leaves of rice varieties during water shortage is evidenced by the high content of hard-to-dissociate fractions of water in the leaves under stress conditions.

The dry weight of various rice cultivars was examined in our subsequent research. The flag leaf weight of the "Lazurniy" variety was 14.1 mg according to the analysis's findings, while the weight of the "Sadaf" variety was 10.6 mg, which was less than that of the "Lazurniy" variety. The reason for the high dry weight of the leaf in the "Lazurniy" variety may be the process of photosynthesis and a large content of synthesis of organic substances delivered to all organs through the root (Figure 4).

The productivity indicator of a certain genotype, which is exhibited as a result of biochemical reactions, enzyme activity, and hormone level, as well as the speed of certain physiological processes in plant tissues, is represented by the accumulation of dry mass. Accumulation of dry substance in the plant depends on the speed of assimilation and synthesis of inorganic and organic substances as a result of its effective use. A positive correlation between productivity and accumulated dry biomass has been reported in Table 1.

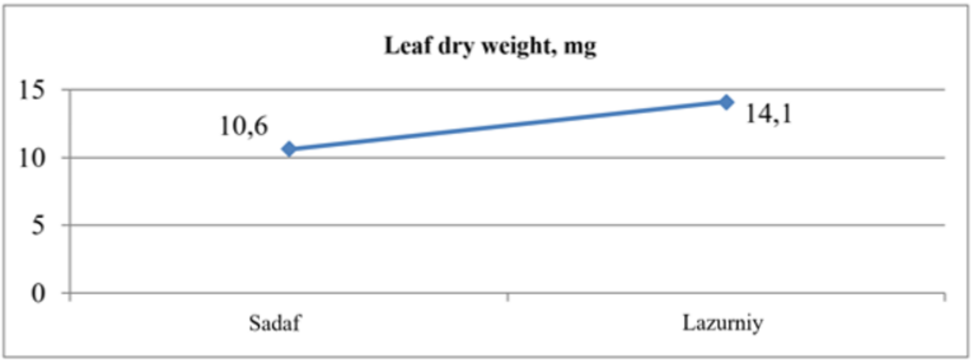

Figure 4. Leaf dry weight.

Table 1. Relationship between productivity and accumulated dry biomass.

Name of varieties	Total water content of leaf, %	Transpiration rate H_2O/1 g wet leaf x 1 hour	Leaf water retention capacity, %	Leaf dry weight, mg
“Sadaf”	94.3	398.5	55.2	10.6
“Lazurniy”	94.2	335.5	64.3	14.1

4 Conclusions

Important physiological indicators of water balance - transpiration rate, water retention properties of leaves, and dry weight of leaves - were found to be insignificantly different in studied rice varietiesThese physiological processes were not seen in the "Sadaf" and "Lazurni" types. It was observed that the "Lazurniy" variety is an intensive type variety, gives a high yield in the optimal agro background, and it is more resistant to water shortage stress than the "Sadaf" variety.

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