

## Certain Physiological Characteristics of Water Metabolism in Local and Foreign Cotton Varieties Under Soil Salinity Conditions

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### Abstract

*This article presents comprehensive data obtained regarding the water metabolism of local and foreign cotton varieties cultivated under conditions of soil salinity. It provides a detailed substantiation of the variations in water metabolism rates across the local Bukhara-8 variety and several foreign varieties, specifically Xinluzao-57, Zhongmian-88, Xinluzao-52, Zhongmian-113, Xinluzao-78, and Zhungtay-2, within both control and experimental variants. The investigation established that the critical physiological parameters defining the water metabolism characteristics of cotton – namely, the water-retaining capacity of the leaves, the intensity of transpiration, and the diurnal leaf water deficit – exhibit a direct and significant dependence on the specific variety, the experimental conditions, and the developmental stages of the cotton plants.*

Keywords: Water metabolism, cotton varieties, soil salinity, water-retaining capacity, transpiration intensity, water deficit.

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### 1. Introduction

In the field of plant sciences, the investigation into the mechanisms of salt tolerance in agricultural crops possesses immense theoretical significance and profound practical importance. The progressive escalation of soil salinity levels on an annual basis continues to exert a deleterious impact on the attainment of high-quality and abundant yields from numerous agricultural species. In arid and semi-arid regions, salinity is identified as one of the primary abiotic stressors; saline soils are extensively distributed across all climatic zones, affecting more than

800 million hectares, which constitutes over 6% of the global land surface [1].

Soil salinity represents a critical environmental factor that is inversely correlated with plant growth and overall productivity. According to certain estimations, between 15% and 23% of the world's total land mass, including a significant portion of areas utilised for agriculture, is comprised of saline soils [2]. The challenges associated with global climate change, the salinisation of irrigated lands, and rapid population growth, combined with the expansion of saline areas, pose a substantial threat to public health, national economies, and ecosystem

stability [3].

Consequently, exploring and deciphering the salt tolerance mechanisms of plants remains one of the most pressing scientific challenges of the modern era. Deepening existing knowledge in this domain provides the essential prerequisites for developing advanced methods in breeding, transgenesis, and the application of physiologically active substances aimed at enhancing the resilience of plants to saline environments.

The water metabolism within plants and the continuous exchange of moisture are vital for the physiological and metabolic processes that regulate cell hydration characteristics, ultimately determining both the quantitative and qualitative aspects of plant growth. During the process of transpiration, the loss of water leads to a reduction in leaf water potential and a corresponding decrease in xylem pressure. While the transpiration of water within the leaves is primarily regulated by the stomatal apparatus, continued transpiration in the absence of sufficient water availability inevitably results in cellular dehydration.

The degree of dehydration in plants is contingent upon a multitude of factors, including:

- Climatic conditions and environmental variables;
- The specific growth and developmental stages of the plants;
- Irrigation regimes and the quality of available water resources.

Among well-irrigated plants, transpiration serves as one of the most effective mechanisms for regulating leaf temperature [4]. When water scarcity occurs and the stomata close as a protective response, transpiration continues only through the cuticle. This results in an increase in temperature, which subsequently leads to heightened stomatal resistance and an accelerated rate of tissue respiration. Under such stressful conditions, the intensity of photosynthesis is severely limited, forcing the plant to consume its own photo-assimilates, which leads to a marked reduction in growth. Furthermore, the accumulation of salts in the root growth zones causes a decrease in osmotic potential and, consequently, a drop in water potential, thereby reducing the volume of bioavailable water that can be absorbed in the rhizosphere [5].

## 2. Methods

In the course of these investigations, the local cotton variety Bukhara-8 and several foreign varieties, namely Xinluzao-57, Zhongmian-88, Xinluzao-52, Zhongmian-113, Xinluzao-78, and Zhungtay-2, were utilised as the primary objects of study.

The experimental trials were conducted under the specific conditions of the meadow-alluvial soils of the Bukhara region. This particular soil type constitutes the predominant portion of the land area within the Bukhara province. Field experiments were primarily carried out across two distinct categories of land: non-saline (control) and moderately saline field plots. All experiments were performed using a fourfold replication design to ensure statistical reliability.

During the conducted research, key physiological parameters defining the water metabolism characteristics of the cotton plants were measured, including:

- The water-retaining capacity of the leaves;
- The intensity of transpiration;
- The diurnal leaf water deficit.

These indicators were systematically determined across both non-saline and moderately saline variants during the critical phenological stages of cotton development, specifically the budding, flowering, and boll-formation stages.

## 3. Results and Discussion

During the course of these investigations, the local cotton variety Bukhara-8 and several foreign varieties, including Xinluzao-57, Zhongmian-88, Xinluzao-52, Zhongmian-113, Xinluzao-78, and Zhungtay-2, were comprehensively evaluated. For each specific variety, two distinct experimental variants were implemented: the first variant represented non-saline soil conditions (control), while the second variant represented moderately saline soil environments. Physiological measurements were systematically recorded during the first, second, and third hours of observation. According to the obtained data, a clear and stable differentiation in the degree of water loss from leaf tissues was observed over the three-hour period during the flowering stage, varying significantly across both experimental variants and varieties.

The findings indicate that the degree of leaf water loss increased progressively over time in all varieties and under both experimental conditions. The lowest rates of

water loss were recorded during the first hour, followed by a significant increase during the second hour, reaching maximum values by the third hour. Specifically, in the Bukhara-8 variety:

- In the first variant, water loss was 12.02% in the first hour, 17.12% in the second hour, and 22.50% in the third hour.

- In the second variant (saline), the recorded values were 10.13%, 15.25%, and 20.47% for the first, second, and third hours, respectively.

In the Xinluzao-57 variety:

- The first variant showed water loss of 13.46% (1st hour), 18.66% (2nd hour), and 23.69% (3rd hour).

- The second variant recorded lower indices of 11.55%, 16.86%, and 22.23%, respectively.

For the Zongmian-88 variety:

- The first variant exhibited loss rates of 19.83%, 24.18%, and 27.27% across the three hours.

- The second variant showed indices of 17.30%, 22.90%, and 25.40%.

Observations for the Xinluzao-52 variety revealed:

- In the first variant: 14.82% (1st hour), 19.95% (2nd hour), and 24.75% (3rd hour).

- In the second variant: 13.10%, 18.75%, and 23.64%.

In the Zhongmian-113 variety, the following data were obtained:

- First variant: 18.05%, 22.45%, and 26.72% water loss.

- Second variant: 16.46%, 20.57%, and 24.25%.

For the Xinluzao-78 variety:

- The first variant recorded 16.18%, 21.06%, and 25.66%.

- The second variant showed 14.94%, 19.64%, and 24.28%.

In the Zhungtay-2 variety, the highest water loss rates were observed:

- First variant: 21.70% (1st hour), 25.86% (2nd hour), and 28.86% (3rd hour).

- Second variant: 20.62%, 24.23%, and 27.13%.

Notably, across all studied varieties, the second variant (moderately saline soil) was characterised by lower water loss rates compared to the first variant. This phenomenon suggests that soil salinity triggers a physiological response that enhances the water-retaining capacity of leaf tissues as an adaptive mechanism. The relatively low water loss during the initial hours indicates a sufficient internal water reserve within the leaf cells. However, the sharp increase in the second hour and the peak evaporation in the third hour signal a substantial shift in the plant's water balance.

In a comparative analysis of the varieties, Zhungtay-2 and Zongmian-88 were distinguished by high water loss rates, indicating a relatively more intensive transpiration process. Conversely, the local Bukhara-8 and foreign Xinluzao-57 varieties demonstrated lower water loss indices, which signifies a superior water-retaining ability. The varieties Xinluzao-52, Zhongmian-113, and Xinluzao-78 were characterised by intermediate results. Overall, it was established that the degree of leaf water loss during the flowering stage is directly dependent on the genotype of the variety, the salinity level of the environment, and the temporal factor. This parameter is crucial for evaluating the water regime of plants; a lower rate of water loss is considered a marker of salt tolerance, enhancing physiological stability, ensuring consistent growth, and preserving yield levels. High water loss, however, exacerbates stress conditions, limits photosynthetic activity, and slows biomass accumulation, reinforcing the necessity of selecting salt-adapted varieties.

Furthermore, the intensity of transpiration was examined during the flowering stage across different time intervals, experimental variants, and varieties, measured in  $\text{mg/m}^2 \cdot \text{min}$ . The study utilized three specific timeframes: 08:00–10:00, 12:00–14:00, and 16:00–18:00.

Transpiration is a fundamental process in managing the water balance of plants. Under optimal non-saline conditions, cotton exhibits maximum transpiration, which enhances the uptake of water and nutrients from the soil and accelerates the diffusion of  $\text{CO}_2$  into the leaf mesophyll. This leads to intensified photosynthesis and increased synthesis of organic matter. The data concerning the impact of water deficiency on transpiration intensity during the budding, flowering, and boll-formation stages are summarized as follows:

- Transpiration rates were consistently higher in non-

saline soils.

– In moderately saline soils, the values significantly decreased, with the lowest indices recorded in the Bukhara-8 variety and the highest in Zhungtay-2 and Zongmian-88.

– Salinity-induced reductions in transpiration intensity were regular across all time intervals, with average values peaking during the hot midday period (12:00–14:00), reflecting the physiological activity of the plants.

Additionally, the impact of salinity on diurnal leaf water deficit was investigated during the 12:00–14:00 period across the budding, flowering, and boll-formation stages. General trends showed that as the developmental stages progressed, the water deficit increased in all varieties, reaching its maximum during the boll-formation stage. Under moderately saline conditions, water deficit values were higher compared to non-saline conditions. The lowest overall water deficit was observed in the Bukhara-8 variety, while the highest were found in Zhungtay-2 and Zongmian-88. These consistent differences between variants indicate the negative impact of salinity on the plant water regime. Varieties with lower water deficit values are considered more resilient, whereas those with higher indices may be more sensitive to stress, providing vital data for future selection and agrotechnical practices.

#### 4. Conclusions

Based on the comprehensive data presented in this study, the following conclusions have been established:

- The water metabolism rates of the local cotton variety Bukhara-8 and the foreign varieties Xinluzao-57, Zhongmian-88, Xinluzao-52, Zhongmian-113, Xinluzao-78, and Zhungtay-2 exhibit significant variations across both control (non-saline) and experimental (moderately saline) variants.

- The fundamental physiological parameters that define these water metabolism characteristics—specifically the water-retaining capacity of the leaves, the intensity of transpiration, and the diurnal leaf water deficit—demonstrate a direct and quantifiable dependence on the specific variety, the environmental soil conditions, and the phenological developmental stages of the cotton plants.

- Soil salinity acts as a primary modulator of water relations, generally leading to a reduction in transpiration intensity while simultaneously triggering an increase in the water-retaining capacity of the leaf tissues as an

adaptive response to osmotic stress.

- Among the studied genotypes, the local variety Bukhara-8 and the foreign variety Xinluzao-57 displayed superior physiological stability and higher water-retention capabilities, suggesting a greater degree of resilience to saline environments compared to the more sensitive Zhungtay-2 and Zongmian-88 varieties.

- The progressive increase in water deficit observed from the budding stage through to the boll-formation stage underscores the critical importance of monitoring water status during the peak reproductive phases to mitigate the negative impacts of salinity on ultimate crop productivity.

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