

Photosynthetic Potential Of Foreign And Local Cotton Varieties Under Saline Soil Conditions

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Abstract

This article presents comprehensive data regarding the intensity of photosynthesis in local and foreign cotton varieties cultivated under soil salinity conditions. The study establishes the specific differences in the net photosynthetic productivity levels of the local *Bukhara-8* variety in comparison with foreign genotypes, namely *Xinluzao-57*, *Zongmian-88*, *Xinluzao-52*, *Zhongmian-113*, *Xinluzao-78*, and *Chjuntay-2*, across both control and experimental variants. It was determined that the photosynthetic intensity of these cotton varieties is directly correlated with their salt tolerance characteristics, varying significantly depending on the specific variety, the experimental conditions, and the developmental stages of the plants. The findings highlight the physiological mechanisms of adaptation and the maintenance of metabolic efficiency in response to abiotic stress factors in diverse cotton germplasm.

Keywords: cotton varieties, soil salinity, photosynthetic intensity, developmental stages, turgor pressure, salt tolerance

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Introduction

Soil salinity represents one of the primary limiting factors for agricultural productivity within the global biosphere. Approximately 20% of the world's

total cultivated land area is currently affected by saline conditions. The intensification of soil salinisation is driven by a combination of factors, including the utilisation of saline water for irrigation, inappropriate agrotechnical practices, insufficient precipitation, high rates of evaporation, the natural weathering of parent rocks, and the overarching impacts of global climate change [1].

The growth and development of plants are subjected to a variety of stress factors. Amongst these, salinity stands as a critical abiotic stressor that exerts a profound negative influence on the overall growth parameters and ultimate yield of agricultural crops [2]. According to current estimates, more than one billion hectares of land worldwide are affected by salinity. In an era where the availability of arable land is progressively diminishing, the continued expansion of salinised areas exacerbates the challenge of global food security, particularly against the backdrop of a rapidly increasing human population [3].

The escalating spread of salinity poses a growing risk to the developmental stability and productivity of agricultural crops, creating serious threats to both agrarian and ecological sustainability. Data from the Food and Agriculture Organisation (FAO) indicate that the total area of salt-affected soils exceeds 833 million hectares, with more than two-thirds of these lands situated in arid and semi-arid climatic zones. Furthermore, the rate of salinisation in cultivated lands is increasing by approximately 10% annually [4].

Cotton (*Gossypium spp.*) is a vital fibre crop cultivated on a global scale. However, its productivity and the quality of the resulting produce are under significant threat due to the intensifying effects of climate change and various abiotic stress factors [5]. Abiotic stresses lead to substantial reductions in global cotton production volumes and a decline in qualitative and quantitative yield indicators. As cotton serves as the primary raw material for the textile industry and a major source of vegetable oil, any reduction in its yield has a direct negative impact on the global economy [6].

Primary abiotic stress factors are considered the leading constraints on cotton productivity. These include adverse environmental conditions such as extreme high and low temperatures, drought, salinity, heavy metal contamination, and radiation. Such stressors disrupt the normal physiological and metabolic processes inherent to the cotton plant [7]. Soil salinity, in particular, impairs water uptake and disrupts ionic balance,

leading to ion toxicity, osmotic stress, oxidative damage, and nutritional deficiencies. Consequently, these disruptions result in stunted growth, leaf chlorosis or necrosis, and yield loss. In cotton plants, salinity increases the shedding of reproductive organs, delays flowering, and reduces both the number and weight of bolls [8].

Second only to drought, salinity is regarded as the most severe abiotic stress factor limiting plant growth and the attainment of optimal crop yields [9]. Salt stress is a detrimental abiotic factor that has rendered nearly 40% of the world's land area saline to some degree [10]. It continuously affects approximately 800 million hectares of land on a global scale [11].

Salinity stress remains a fundamental factor limiting agricultural productivity across the entire biosphere [12]. Given that approximately 20% of global crop areas are impacted by salt stress, understanding its effects is crucial. While the germination of cotton seeds is heavily dependent on environmental conditions, the subsequent development of seedlings is governed by a complex interplay between genetic characteristics, seed quality, and ecological variables [13].

Salinity significantly reduces seed viability, plant development, and crop productivity. The primary causes of decreased germination are identified as the restriction of water entry into the seed due to high salt concentrations or the direct toxic effects of ions. Furthermore, salt can inhibit the activity of specific enzymes that play a vital role during the germination process. As a result, the germination of cotton seeds and the emergence of seedlings are not only reduced but also significantly delayed [14].

The progressive salinisation of agricultural land is a major global issue, posing a severe threat to cotton cultivation—a crop that serves as the backbone of the textile industry and a key economic driver for many nations. Salt stress negatively impacts various stages of cotton growth and development, particularly during the seedling stage, where it hinders seed germination, root elongation, and the overall vitality of the plant [15,16].

Research Materials and Methodology

The experimental investigations were conducted utilizing a diverse selection of cotton germplasm, comprising the local variety *Bukhara-8* and several prominent foreign cultivars, namely *Xinluzao-57*, *Zongmian-88*, *Xinluzao-52*, *Zhongmian-113*, *Xinluzao-78*, and *Chjuntay-2*. The research was carried out within the specific agro-ecological conditions of the Bukhara region, characterized by meadow-alluvial soil types. This

particular soil classification represents the predominant soil mantle across the majority of the Bukhara province's agricultural territories.

Field experiments were strategically established and implemented across two distinct environmental backgrounds: non-saline (control) and moderately saline field plots. To ensure statistical reliability and scientific precision, all experiments were organised using a fourfold replication design.

In the course of the conducted research, several critical physiological parameters defining the water metabolism characteristics of the cotton plants were systematically evaluated. These measurements included:

- The water-retention capacity of the leaf tissues;
- The intensity of leaf transpiration;
- The diurnal water deficit within the leaves.

These physiological indicators were determined and recorded across both the non-saline and moderately saline experimental variants during the key ontogenetic stages of cotton development, specifically at the squaring (budding), flowering, and boll-formation phases.

Results and Discussion

The adequate provision of water to plants is of paramount significance for the process of photosynthesis. This is primarily because the maintenance of turgor pressure within the cells of leaf tissues ensures the active and efficient functioning of plastids. Conversely, any disruption in the water balance leads to a significant decline in the overall photosynthetic productivity of the plants.

During the course of the present research, the impact of soil salinity on the photosynthetic intensity of various cotton varieties was systematically investigated under field experimental conditions. The values for this physiological parameter were determined across the critical developmental phases of the cotton plants, specifically during the squaring, flowering, and boll-formation stages. It is well-established that cultivated plants growing in natural environments frequently encounter the adverse effects of soil salinity throughout their growth and development, which inevitably triggers substantial alterations in their water balance.

The influence of salinity on photosynthetic intensity was rigorously analysed across different varieties, developmental stages, and experimental variants. The studies were conducted during the squaring, flowering, and boll-formation phases, employing two distinct variants for each variety:

— The first variant represented non-saline soil conditions (control).

— The second variant represented moderately saline soil conditions.

The results of these measurements, expressed as indicators of photosynthetic intensity in units of $\text{g/m}^2 \cdot \text{h}$, are detailed below:

In the *Bukhara-8* variety, the squaring stage revealed a value of 1.42 in the first variant and 1.24 in the second variant. During the flowering stage, these figures rose to 1.83 and 1.62, respectively. At the boll-formation stage, results of 1.67 and 1.48 were recorded. In this particular variety, salinity caused a reduction in photosynthetic intensity across all developmental stages.

The *Xinluzao-57* variety exhibited values of 1.26 and 1.06 at the squaring stage. During flowering, values of 1.68 and 1.40 were observed, while the boll-formation stage yielded results of 1.54 and 1.23. Similar to the previous variety, a marked decrease in photosynthetic intensity was noted under saline conditions.

For the *Zongmian-88* variety, values of 0.62 and 0.43 were recorded during squaring. At the flowering stage, the intensity reached 0.98 and 0.70, while at the boll-formation stage, the results were 0.84 and 0.59. This variety demonstrated generally low photosynthetic intensity, with the negative impact of salinity being highly pronounced.

In the *Xinluzao-52* variety, values of 1.12 and 0.86 were identified during squaring. The flowering stage showed results of 1.45 and 1.18, and the boll-formation stage recorded 1.38 and 1.11. This cultivar displayed a moderate level of tolerance to salt stress.

The *Zhongmian-113* variety showed values of 0.86 and 0.62 at the squaring stage. During flowering, values of 1.16 and 0.92 were documented, and at the boll-formation stage, the results were 1.02 and 0.74. A significant reduction in photosynthetic capacity was evident in this variety under saline conditions.

The *Xinluzao-78* variety recorded values of 0.90 and 0.67 during squaring. At flowering, the results were 1.23 and 0.98, and at the boll-formation stage, values of 1.15 and 0.88 were observed, indicating a moderate level of resilience.

In the *Chjuntay-2* variety, the lowest photosynthetic intensities were observed, with values of 0.46 and 0.18 during squaring. During flowering, these reached 0.85 and 0.58, and at the boll-formation stage, values of 0.70 and 0.46 were recorded. This variety experienced the most severe impact from soil salinity.

In general, the intensity of photosynthesis reached its peak during the flowering stage across all studied varieties. Photosynthetic activity was relatively lower during the squaring stage and showed a slight decline during the boll-formation phase. This progression is explained by the inherent physiological development characteristics of the plants.

Under saline conditions, the intensity of photosynthesis decreased across all developmental stages. This physiological process is directly linked to the increase in osmotic pressure within the leaves. In a saline environment, water absorption becomes increasingly difficult, leading to a reduction in cellular turgor. This condition necessitates the closure of stomata to prevent excessive water loss. However, stomatal closure restricts the exchange of CO_2 , thereby inhibiting the photosynthetic process. Furthermore, salinity contributes to a reduction in chlorophyll content, which impairs the absorption of light energy and ultimately results in a decrease in overall photosynthetic efficiency.

Conclusions

An in-depth analysis across the studied cotton varieties reveals that the local cultivar *Bukhara-8* and the foreign variety *Xinluzao-57* maintained relatively high levels of photosynthetic intensity even under stress conditions. These specific varieties are characterised by a notable degree of resilience and can be classified as salt-tolerant genotypes. In contrast, the *Xinluzao-52* and *Xinluzao-78* varieties demonstrated moderate physiological indicators, reflecting an intermediate level of adaptation to saline environments.

The experimental data further show that the *Zhongmian-113* variety exhibited a lower photosynthetic intensity, while the *Zongmian-88* and *Chjuntay-2* varieties recorded the most substantial declines in metabolic performance. These cultivars are considered highly sensitive to soil salinity. Specifically, the *Chjuntay-2* variety showed a sharp and critical reduction in photosynthetic activity across all developmental stages, indicating an extremely low capacity for physiological adaptation to salt stress. A similarly sensitive response was documented for the *Zongmian-88* variety.

The findings of this research carry significant implications for the strategic selection of cotton varieties suitable for cultivation in salt-affected agricultural landscapes. Varieties that sustain a higher intensity of photosynthesis under stress are better equipped to preserve their yield potential. By selecting and implementing salt-tolerant cultivars in such

environments, it is possible to ensure stable and sustainable crop productivity.

Furthermore, these results serve as a scientific basis for the development of targeted agrotechnical strategies. In saline conditions, it is imperative to organize precise irrigation schedules, leaching practices, and balanced fertilization systems. Such interventions can assist in the partial restoration and optimization of the photosynthetic process. Ultimately, the data obtained from this study provide a deeper understanding of the impact of salinity on plant physiology, confirming that photosynthetic intensity serves as a reliable proxy for the overall physiological health and adaptive capacity of the cotton plant.

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