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EFFECT OF SOIL SALINITY ON WATER EXCHANGE PARAMETERS OF FINE-FIBER COTTON VARIETIES

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Abstract
The article discusses the effects of soil salinity on some water exchange parameters of fine-fiber cotton varieties Surkhon-111 and Termiz-3 based on experiments. The transpiration rate and water retention rate of leaves of cotton varieties significantly depend on the development phases of the varieties, and it was noted that the transpiration rate is highest at the boll stage and the water retention rate of leaves is highest at the budding stage.

Keywords: Fine-fiber cotton, water exchange, soil salinity, transpiration rate, water retention properties of leaves, resistance.

Introduction

To meet the global demand for food by the year 2050, agricultural production must increase by approximately **60%**. This urgent need requires substantial efforts to improve agricultural productivity. One of the most effective approaches to addressing this challenge is the development of salt-tolerant crop varieties. Understanding the physiological and biochemical mechanisms underlying plant tolerance to salinity is essential for breeding such crops and mitigating future food shortages [1].

Saline soils currently occupy about 3.1% of the Earth's total land area, amounting to nearly 397 million hectares. High concentrations of soluble salts in the soil significantly reduce the productivity of many crops worldwide, leading to annual economic losses estimated in billions of dollars [2].

Soil salinity negatively affects primary and lateral root growth, leaf expansion and area, stem thickness, plant height, and biomass accumulation in both shoots and roots. In cotton, prolonged exposure to salt stress exacerbates these adverse effects. As a result, mature cotton plants often exhibit delayed boll formation, reduced fruit set, increased fruit shedding, and late maturation. Furthermore, seed weight, fiber length, fiber strength, and overall yield decline considerably, especially when cotton plants are exposed to saline conditions for extended periods or throughout their entire life cycle [3].

Materials and Methods

The study was conducted using two fine-fiber cotton varieties, Surxon-111 and Termiz-3. Throughout the research, phenological observations, field experiments, cultivation and crop management practices, biometric measurements, and morphological, physiological, and comparative analyses were performed.

Phenological observations were carried out for all experimental variants. The following growth and developmental stages of the plants were recorded: true leaf phase, budding, onset and full flowering, boll formation, and ripening.

Plant density was determined in two plots (each 0.5 m²) allocated for every replication. Beginning from the third true leaf stage, plant height was measured every 15 days on 25 randomly selected plants. Measurements were taken from the root collar to the apex of the main stem.

For agrochemical analysis, soil samples were collected from the experimental plots to a depth of 1 meter, at 0.2 m intervals down to 1.0 m, and then every 50 cm thereafter, with ten replications. The samples were analyzed under laboratory conditions according to standard analytical procedures accepted in soil science.

Results and Discussion

To increase plant biomass by 1 g, approximately 500 g of water must be absorbed by the root system, transported through the plant, and released into the atmosphere from the surfaces of vegetative organs. Water possesses unique physical and chemical properties, making it vital for all cellular processes. Even minor disturbances in the water regime can cause profound metabolic changes in plant tissues.

It is well established that leaf transpiration is one of the essential physiological processes in plants. It protects them from overheating and desiccation under hot and dry conditions, facilitates the movement of water and dissolved substances throughout the plant body, and plays a key role in gas exchange. The temperature of a leaf undergoing active transpiration is about 7°C lower than that of a wilted, non-transpiring leaf.

The rate of water consumption for transpiration is mainly determined by solar radiation and soil moisture availability. Transpiration intensity varies with season, time of day, meteorological conditions, biological characteristics of the plant, cultivation practices, and particularly, the degree of soil salinity. As one of the most important physiological processes, transpiration not only regulates plant water exchange but also moderates tissue temperature and ensures the movement of water and solutes within the plant.

Under the moderately saline soils of Bukhara region, all studied fine-fiber cotton varieties absorbed the greatest amount of water between 12:00 and 14:00 hours. However, the magnitude of water uptake varied among varieties. The experiments showed that the transpiration rate of cotton leaves is strongly dependent on the plant’s growth phase, reaching its maximum during the formation of generative organs, i.e., during flowering and boll formation stages.

In non-saline and moderately saline soils, transpiration intensity was recorded from 08:00 to 20:00 hours. According to the data obtained, at 20:00 hours the Surxon-111 variety had a daily maximum transpiration rate of 1202.4 mg/g·h, while Termiz-3 reached 1973.2 mg/g·h (observed on June 23). Both varieties exhibited lower rates in the evening compared to midday measurements.

Measurements of transpiration intensity were first taken at the true leaf stage, then one month later

(June 23), and again during the full flowering and boll formation stages. The data revealed that transpiration rates during full flowering were significantly higher than at the early flowering stage, as cotton plants had begun simultaneous flowering and initial boll formation. This is explained by the sequential flowering pattern of cotton — flowers first appear on the lower nodes and gradually progress upward. During the boll formation phase, transpiration intensity reached its highest levels across all varieties studied.

In summary, the analysis of transpiration dynamics across different cotton varieties revealed a consistent pattern: during the early vegetative stages, plants transpire less water; transpiration peaks during flowering and boll formation; and subsequently declines as the plants approach maturity. In all varieties, transpiration activity was lowest in the early morning and late evening, and peaked between 12:00 and 14:00 hours. Thus, the water requirements of fine-fiber cotton varieties follow a common physiological pattern, and the findings of this study can be used to determine optimal irrigation schedules and salinity management strategies for improved cotton productivity under saline conditions.

It was found that the maximum transpiration rate for all studied cotton varieties occurred between 12:00 and 14:00 hours. The leaves of the examined varieties exhibited clear diurnal and seasonal fluctuations in transpiration intensity, with a sharp decline observed toward the end of the growing season. Under the moderately to highly saline soils of the Surxondaryo region, the highest transpiration rates for Surxon-111 and Termiz-3 varieties were recorded during the summer months (June–July). These values were directly influenced by air temperature, soil salinity, and the biological characteristics of the respective varieties.

During the initial stages of ontogenesis, transpiration intensity in cotton plants was relatively low. It increased markedly during full flowering and boll-formation stages, followed by a decline in the later stages of vegetation.

Photosynthesis and transpiration are two closely interrelated physiological processes that not only ensure plant survival under stressful conditions but also determine their ability to achieve full growth and productivity. Transpiration protects plants from overheating and dehydration under hot and arid conditions, promotes the movement of water and dissolved nutrients throughout the plant body, and plays a crucial role in gas exchange.

In plants growing under moderate soil moisture, the total water content fluctuated throughout the day, corresponding closely with changes in transpiration intensity. The amount of water expended through transpiration serves as an indicator of a plant's water demand and requirement. The determination of water expenditure for transpiration depends on several factors, including root mass and volume, above-ground biomass, osmotic pressure of root cell sap, depth of groundwater, precipitation, air temperature and relative humidity, soil moisture reserves, and plant water potential.

The intensity of transpiration is largely governed by the stomatal condition and the water content in the leaves, which together determine the plant's water status. In some cases, rapid leaf dehydration disrupts stomatal regulation of water loss, resulting in decreased photosynthetic activity.

Analysis of the research results revealed a wide range of variation in water-exchange parameters, reflecting the ecological and physiological plasticity of cotton species that have evolved over long periods under diverse environmental conditions.

The rate of water loss is inversely related to the leaf's water-holding capacity—a key indicator of plant water relations that significantly influences various physiological processes and ultimately yield. The ability of leaves to retain water is often considered an indicator of drought tolerance, as plants with higher water-holding capacity tend to withstand unfavorable environmental conditions more effectively.

In field practice, cotton farmers and agronomists use this parameter as a diagnostic criterion to assess varietal tolerance to different levels of soil salinity, helping to identify salt-tolerant cotton cultivars suitable for saline environments.

It is well known that plant adaptation and stabilization under adverse environmental conditions are accompanied by an increase in water-retaining forces within tissues. The ability of plants to retain a significant portion of the water present in their tissues represents a universal physiological response to both soil moisture deficit and situations where sufficient water is present but cannot be absorbed by the plant due to soil salinity.

Hence, the manifestation of factors that either intensify or prevent water loss must be assessed in terms of the water-holding capacity of tissues, or in other words, their resistance to forced dehydration—a property often interpreted through the ratio of different water fractions in the tissues. The leaf water-holding capacity (WHC) is evaluated by the amount of residual water remaining in the leaves after a defined period of drying. During ontogeny, the amount of residual water in cotton leaves changes significantly.

The water-retention ability of leaves depends on multiple factors, including soil moisture, soil salinity, air temperature, relative humidity, and the biological characteristics of the variety. Scientific literature provides limited data on the water-holding properties of cotton leaves; therefore, specific investigations were carried out to clarify this aspect.

Experimental results showed that the maximum leaf water-holding capacity occurred at the budding (square formation) stage, reaching 62.5% in the Surxon-111 variety and 61.8% in Termiz-3. Analysis of the seasonal variation in leaf water retention revealed a gradual decline during the boll-opening phase. For plants grown in non-saline soils, the water-holding capacity during boll opening was approximately 20% lower than at the budding stage.

Based on these data, the water-holding capacity of cotton leaves in non-saline environments decreased gradually from the budding to flowering and boll-opening phases. Specifically, in the budding stage, the capacity was 61.8% for Termiz-3 and 62.5% for Surxon-111; during flowering, these values decreased slightly to 60.4% and 62.5%, respectively; and by the ripening phase, before defoliation, reached minimum levels of 55.7% (Termiz-3) and 56.5% (Surxon-111). A similar trend was observed under moderately saline soil conditions.

Conclusions

According to the obtained results, under moderately saline conditions, the leaf water-holding capacity at the budding stage was 39.4% for the Termiz-3 variety and 39.8% for Surxon-111. During the flowering stage, the values decreased to 36.8% and 37.2%, respectively, and reached their minimum before defoliation—33.7% in Termiz-3 and 33.6% in Surxon-111.

These findings indicate that soil salinity substantially reduces the water-holding capacity of cotton leaves, especially during the later stages of plant development. The reduction in water retention reflects the physiological stress imposed by salinity on leaf tissues, leading to decreased turgor

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stability and diminished resistance to dehydration.

Overall, the results demonstrate that the Surxon-111 and Termiz-3 fine-fiber cotton varieties exhibit moderate tolerance to salinity, maintaining relatively higher water-holding capacity at the early growth stages. These physiological characteristics can be considered as diagnostic indicators in evaluating varietal salt tolerance and optimizing irrigation management strategies in saline environments of southern Uzbekistan.

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