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THE IMPACT OF SOIL SALINITY ON THE GROWTH DYNAMICS OF FOREIGN AND LOCAL COTTON VARIETIES

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Abstract
This article comprehensively investigates the growth dynamics and developmental characteristics of both local and foreign cotton varieties cultivated under saline soil conditions. The empirical research was systematically conducted during the critical developmental stages of squaring, flowering, and boll formation, carefully comparing plant responses in both non-saline and moderately saline soil environments. According to the obtained results, it was conclusively determined that soil salinity significantly diminished the overall growth rate across all the examined agricultural varieties. In particular, the fundamental disruption of vital physiological processes, encompassing water exchange mechanisms and mineral nutrition absorption, served as the primary causative factor for the notable reduction in overall plant height. While the 'Bukhara-8' and 'Xinluzao-78' cultivars successfully maintained relatively superior growth indicators and demonstrated a commendable degree of resilience under adverse saline conditions, the 'Zhongmian-88' and 'Zhongmian-113' varieties were distinctly characterised by their pronounced sensitivity and vulnerability to salt stress. The scientific findings derived from this study hold paramount importance for the targeted selection of salt-tolerant varieties specifically suited for cultivation in salinised agricultural areas, the continuous advancement of contemporary breeding programmes, and the strategic optimisation of applied agrotechnical measures to ensure sustainable crop yields.

Keywords: Cotton varieties, Soil salinity, Growth dynamics, Salt stress tolerance, Physiological processes, Agrotechnology.

Introduction

In the context of contemporary climatic conditions, the optimisation of sowing dates constitutes one of the most accessible and climate-adaptive management interventions. This approach is of paramount importance for aligning the phenological stages of cotton, capitalising efficiently on seasonal precipitation, and facilitating robust adaptation to escalating temperatures [1,2].
It remains imperative to refine the frameworks used for evaluating climatic risks within agricultural production by employing dynamic crop modelling alongside long-term production scenarios [3,4,5].
Furthermore, an elevation in ambient temperature inherently exacerbates agricultural water demand [6], particularly during the critical developmental stages of flowering and boll maturation. Consequently, rising temperatures, recurrent drought, the progressive limitation of freshwater

resources [7], and the instability of precipitation regimes are projected to exert a profoundly deleterious impact upon the phenology and overall productivity of cotton in established cultivation zones, most notably in arid regions where annual rainfall falls below 200 millimetres. In this context, drip irrigation, fundamentally predicated upon regulated water application, affords a critical mechanism for maximising water-use efficiency and streamlining irrigation management [8,9].

Concurrently, the successful deployment of such systems necessitates the real-time acquisition of region-specific agroclimatic data, thereby demanding precise, evidence-based recommendations concerning optimal sowing dates, seeding rates, water and fertiliser requirements, and ideal crop densities. This signifies that the cotton industry must cultivate a more profound comprehension of prospective climatic shifts and actively employ advanced meteorological forecasting tools to conceptualise and implement sustainable agrotechnologies. Ultimately, the establishment of a climate-smart cotton cultivation paradigm requires the seamless integration of highly reliable climate prognoses with sophisticated decision-support instruments [10,11].

Computational systems engineered to model crop growth and developmental trajectories are extensively utilised in the rigorous assessment of agricultural production capacity. Moreover, these models are critically important for investigating the complex response mechanisms of diverse agro-ecological zones to fluctuating weather patterns, sustained climatic shifts, and varied agricultural management regimes.

Fundamentally, physiological growth processes undergo drastic modifications under the detrimental influence of adverse environmental factors. The onset of a water deficit intrinsically decelerates the overarching growth of the plant as well as the formation of its developing organs; under sustained drought conditions, the subsequent reduction in both biological biomass and economic yield is inextricably linked to this suppression of growth dynamics. Similarly, soil salinity retards growth rates and exerts a strictly negative influence upon crop quality and viability across all developmental stages. It has been scientifically documented that stress factors can elicit a spectrum of physiological responses within plants, and those specific varieties demonstrating an exceptional degree of resilience to severe stress are correspondingly recognised as highly productive cultivars.

In order to sustain optimal physiological processes, plants fundamentally require an adequate and continuous supply of moisture. Crucially, all essential mineral nutrients absorbed by the plant must exist in a fully water-soluble state. These dissolved anions and cations are subsequently assimilated via the root system, translocating and distributing systematically throughout the entire plant structure. Under conditions of environmental water scarcity, the active absorption of both water and essential nutrients by the plant is severely impeded. If this water deficit is further compounded by underlying soil salinity, the physiological ingress of these vital resources becomes even more acutely restricted. This synergistic effect, in turn, exerts a significantly detrimental impact upon the internal water balance of the organism, ultimately resulting in a severe and debilitating water deficit within the plant tissues.

Research Objects and Methods

Throughout the course of the empirical investigations, the local cotton cultivar 'Bukhara-8' alongside several foreign varieties, specifically 'Xinluzao-57', 'Zhongmian-88', 'Xinluzao-52',

'Zhongmian-113', 'Xinluzao-78', and 'Zhongtai-2', were systematically utilised as the primary subjects of study. The comprehensive field experiments were conducted under the specific environmental conditions characterised by the meadow-alluvial soils intrinsic to the Bukhara region. Significantly, this particular pedological classification constitutes the predominant soil type across the vast majority of agricultural arable lands within the aforementioned province.
The *in vivo* field trials were predominantly established within both strictly non-saline and moderately salinised agricultural plots to facilitate a rigorous and objective comparative analysis. To ensure the high statistical reliability, accuracy, and robust validity of the obtained empirical data, all experimental procedures were meticulously designed and executed using a standardised methodological framework comprising four analytical replications.
Within the scope of the executed scientific research, the multifaceted impact of soil salinity upon the overarching physiological growth and developmental processes of the selected cotton varieties was thoroughly investigated. This systematic evaluation was conducted specifically during the critical ontogenetic phases of squaring, flowering, and boll formation. Concurrently, the study rigorously assessed crucial physiological parameters defining the fundamental water exchange characteristics of the cultivated plants. This comprehensive eco-physiological assessment primarily encompassed the precise measurement of foliar water retention capacity, the overall intensity of the transpiration rate, and the specific diurnal water deficit continuously experienced by the cotton leaves throughout the experimental period.

Results and Discussion

According to the presented empirical data, the 'Bukhara-8' cultivar demonstrated a growth height of 50.4 cm in the first variant (non-saline) and 42.0 cm in the second variant (saline) during the squaring stage. During the flowering stage, these indicators were recorded at 75.6 cm and 67.1 cm, respectively. Subsequently, at the boll formation stage, plant heights reached 108.6 cm and 99.8 cm, unequivocally indicating a decline in the overall growth rate under saline environmental conditions. For the 'Xinluzao-57' variety, the recorded heights during the squaring stage were 47.8 cm and 40.3 cm. Throughout the flowering stage, measurements were 64.0 cm and 57.6 cm, whereas the boll formation stage yielded results of 94.5 cm and 86.2 cm. In this particular cultivar as well, soil salinity manifestly diminished the intensity of growth. The 'Zhongmian-88' variety exhibited a growth of 41.6 cm and 35.4 cm during the squaring phase. During flowering, heights of 65.3 cm and 56.3 cm were observed, while at the boll formation stage, the plants measured 95.7 cm and 85.4 cm, thereby demonstrating a remarkably pronounced susceptibility to saline stress. Furthermore, the 'Xinluzao-52' cultivar displayed a growth of 45.6 cm and 38.0 cm during squaring. At the flowering stage, the results were 62.8 cm and 55.3 cm, and during boll formation, they reached 91.0 cm and 83.4 cm, reflecting a moderate overarching growth rate in response to the applied conditions.
In the case of the 'Zhongmian-113' variety, the documented growth parameters during the squaring stage were 43.2 cm and 36.0 cm. During the flowering phase, these figures were precisely determined to be 61.9 cm and 55.2 cm. At the subsequent boll formation stage, the measured outcomes were 90.5 cm and 81.2 cm. Consistent with the other findings, this specific cultivar experienced a significant reduction in its developmental progression under saline conditions. Conversely, the 'Xinluzao-78' variety recorded heights of 47.4 cm and 41.5 cm during the squaring

stage. Throughout the flowering period, the measurements reached 65.4 cm and 58.3 cm, and at the boll formation stage, the plant height culminated at 94.7 cm and 87.8 cm. These compelling results suggest that this particular variety possesses a moderate degree of tolerance to soil salinity. The 'Zhongtai-2' cultivar demonstrated a growth height of 44.7 cm and 38.2 cm during the critical squaring stage. As the plants progressed to the flowering stage, the heights were recorded at 63.7 cm and 57.5 cm. During the final boll formation phase under investigation, the results were 94.9 cm and 86.0 cm. Evidently, the detrimental impact of soil salinisation was clearly perceptible in the growth dynamics of this variety as well.

In general terms, across all the investigated cotton varieties, the intensity of vegetative growth was observed to be at its lowest during the squaring stage, progressed to a moderate level during the flowering stage, and ultimately reached its maximum peak during the boll formation phase. This consistent developmental pattern is intrinsically linked to the natural physiological ontogenesis of the plants. However, under the specific conditions of soil salinity, a systematic and continuous deceleration in the growth rate was meticulously recorded across all developmental stages. This overarching suppressive process is scientifically attributed to the profoundly negative impact of salt stress on the plant's fundamental mechanisms of water exchange and mineral nutrient assimilation. Within a highly saline soil environment, the physiological absorption of both vital water molecules and essential nutritional elements by the root system is severely restricted. Consequently, the crucial cellular processes of division and elongation are significantly retarded, which inexorably leads to a marked reduction in the overall morphological height of the plant.

When conducting a comparative cross-varietal analysis, it becomes evident that the 'Bukhara-8' and 'Xinluzao-78' cultivars successfully maintained relatively superior growth indicators despite the adverse environmental constraints. Consequently, these specific varieties are scientifically classified as possessing a robust tolerance to soil salinity. In contrast, the 'Xinluzao-57' and 'Zhongtai-2' varieties manifested moderate developmental indicators. Conversely, the 'Zhongmian-88' and 'Zhongmian-113' cultivars proved to be highly sensitive and vulnerable to saline stress. Furthermore, a substantial and noteworthy decline in overarching growth parameters was similarly documented in the 'Xinluzao-52' variety.

A robust and statistically significant correlation is readily discernible between the distinct phenological stages and the applied experimental variants. Across all three evaluated developmental phases, the inherent growth intensity observed in the first variant (non-saline control) was consistently superior to that of the second variant (saline conditions). This prevailing circumstance clearly corroborates the fundamental principle that as the concentration of soil salinity escalates, the corresponding rate of vegetative growth diminishes proportionately. During the initial squaring stage, the inhibitory effect of salinity was observed to be relatively less pronounced. However, as the plants transitioned into the flowering stage, this detrimental impact intensified significantly. The most substantial and maximal divergence between the variants was documented during the boll formation stage. It is during this critical phase that the plants have accumulated their maximum biological biomass, thereby naturally increasing their physiological sensitivity and vulnerability to salt-induced stress. Consequently, a strong positive correlation is maintained between the progressive developmental stages.

Furthermore, it was systematically observed that those specific cultivars exhibiting taller morphological statures during the early squaring stage consistently maintained superior height outcomes throughout the subsequent flowering and boll formation phases. This persistent phenomenon is directly associated with the intrinsic genetic potential inherent to these particular varieties. Conversely, a distinct negative correlation is conspicuously present between the experimental variants; specifically, as the severity of salinisation intensifies, the overall growth intensity is correspondingly suppressed. This established negative trend remains remarkably stable and consistent across the entire spectrum of the examined cotton varieties. Finally, it is crucial to note that there is a direct, quantifiable interrelationship between the intensity of vegetative growth and the corresponding rates of photosynthesis, alongside the overall chlorophyll concentration within the plant tissues.

Conclusion

Varieties characterised by a high rate of photosynthesis inherently exhibit a correspondingly high intensity of vegetative growth. Under the adverse conditions of soil salinity, the photosynthetic process is markedly suppressed, which consequently leads to a significant deceleration in overall plant development. The empirical findings derived from this study hold paramount importance for the targeted selection of highly suitable cotton cultivars intended for cultivation within salinised agricultural environments. Cultivars that successfully maintain a robust growth intensity under such demanding conditions are scientifically classified as being highly resilient to salt-induced stress. Crucially, these resilient varieties are capable of maintaining relatively stable and consistent crop yields despite environmental constraints. Conversely, those varieties that are physiologically sensitive to salinity experience a drastic and precipitous decline in overall agricultural productivity. For this fundamental reason, it is absolutely essential to prioritise salt-tolerant cultivars within the framework of ongoing agricultural breeding and selection programmes.

Furthermore, the obtained results are highly instrumental in the strategic planning and implementation of advanced agrotechnical measures. In salinised arable lands, the precise determination and strict regulation of irrigation norms are an absolute necessity. Additionally, it is imperative to conduct regular and systematic soil leaching procedures to mitigate the accumulation of toxic salts. The rigorous optimisation of the applied fertilisation system is equally demanded to support plant nutrition effectively. The comprehensive application of these targeted interventions serves to facilitate the partial restoration of the plant's inherent growth intensity. The quantitative data delineated in the corresponding tables unequivocally illustrate the complex and multifaceted impact of soil salinity on the overarching developmental trajectory of the plant. Ultimately, the measured intensity of growth serves as a highly reliable indicator, accurately reflecting the general physiological state and overall vitality of the agricultural crop.

References

1. Khatri-Chhetri, A., Aryal, J. P., Sapkota, T. B., & Khurana, R. (2016). Economic benefits of climate-smart agricultural practices to smallholder farmers in the Indo-Gangetic plains of India. Current Science.
2. Zhang, Y., Zhang, L., Yang, N., Huth, N., Wang, E., van der Werf, W., Evers, J. B., Wang, Q., Zhang, D., Wang, R., Gao, H., & Anten, N. P. R. (2019). Optimized sowing time windows mitigate climate risks for oats production under cool semiarid growing conditions. Agricultural and Forest Meteorology.

3. Zhang, L., Van Der Werf, W., Cao, W., Li, B., Pan, X., & Spiertz, J. H. J. (2008). Development and validation of SUCROS-cotton: A potential crop growth simulation model for cotton. NJAS - Wageningen Journal of Life Sciences.
4. Chao, C., Yanmei, P., Xuebiao, P., & Lizhen, Z. (2015). Impacts of climate change on cotton yield in China from 1961 to 2010 based on provincial data. Journal of Meteorological Research.
5. Li, Y., Li, N., Javed, T., Pulatov, A. S., & Yang, Q. (2024). Cotton yield responses to climate change and adaptability of sowing date simulated by AquaCrop model. Industrial Crops and Products, 212.
6. Jans, Y., Von Bloh, W., Schaphoff, S., Muller, C., & Jans, Y. (2021). Global cotton production under climate change: Implications for yield and water consumption. Hydrology and Earth System Sciences, 25.
7. Rahman, M. H. U., Ahmad, A., Wajid, A., Hussain, M., Rasul, F., Ishaque, W., Islam, M. A., Shelia, V., Awais, M., Ullah, A., Wahid, A., Sultana, S. R., Saud, S., Khan, S., Fahad, S., Hussain, S., & Nasim, W. (2019). Application of CSM-CROPGRO-Cotton model for cultivars and optimum planting dates: Evaluation in changing semiarid climate. Field Crops Research, 238.
8. Ma, Z., Liu, J., Wen, Y., Zhang, J., Yin, F., Guo, L., Li, W., He, J., Ma, J., Liang, Y., & Wang, Z. (2024). Optimizing cotton yield through appropriate irrigation water salinity: Coordinating above- and below-ground growth and enhancing photosynthetic capacity. European Journal of Agronomy, 154.
9. Wang, H., Wu, L., Cheng, M., Fan, J., Zhang, F., Zou, Y., Chau, H. W., Gao, Z., & Wang, X. (2018). Coupling effects of water and fertilizer on yield, water and fertilizer use efficiency of drip-fertigated cotton in northern Xinjiang, China. Field Crops Research, 219.
10. Zhang, Y., Zhang, L., Yang, N., Huth, N., Wang, E., van der Werf, W., Evers, J. B., Wang, Q., Zhang, D., Wang, R., Gao, H., & Anten, N. P. R. (2019). Optimized sowing time windows mitigate climate risks for oats production under cool semiarid growing conditions. Agricultural and Forest Meteorology.
11. Li, F., Yu, D., & Zhao, Y. (2019). Irrigation scheduling optimization for cotton based on the AquaCrop model. Water Resources Management.
12. Ashraf, M., Arshad, A., Patel, P. M., Khan, A., Qamar, H., Siti-Sundari, R., Ghani, M. U., Amin, A., & Babar, J. R. (2021). Quantifying climate-induced drought risk to livelihood and mitigation actions in Balochistan. Natural Hazards, 109.
13. Ahmad, S., Nadeem, M., Abbas, G., Fatima, Z., Zeb Khan, R. J., Ahmed, M., Ahmad, A., Rasul, G., & Azam Khan, M. (2016). Quantification of the effects of climate warming and crop management on sugarcane phenology. Climate Research.