



The effect of the use of biostimulants in the care of foreign and local cotton varieties on plant growth, development and yield (on the example of soil and climatic conditions of the Fergana region)

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Annotatsiya

This study investigates the effect of applying biostimulators in the cultivation of foreign and local cotton varieties on plant growth, development, and productivity. Cotton is one of the most important agricultural crops in Uzbekistan and many other cotton-producing countries, and the use of environmentally friendly technologies has become a priority in sustainable agriculture. The research examines both foreign and indigenous varieties under identical field conditions, comparing the physiological responses, morphological traits, and yield indicators when treated with biostimulators. Results demonstrated that biostimulators enhanced root and shoot development, improved photosynthetic activity, and increased boll formation, ultimately leading to higher productivity. Moreover, the study highlights the economic feasibility and ecological safety of biostimulator application in cotton production. These findings may serve as a basis for developing innovative agronomic practices aimed at increasing cotton yield and quality while reducing the need for chemical fertilizers and growth regulators.

Kalit soʻzlar: Cotton, biostimulators, growth and development, yield, foreign varieties, local varieties, sustainable agriculture.

Introduction

Cotton (*Gossypium hirsutum* L.) is one of the world's most important industrial crops, serving as a critical source of natural fiber and playing a vital role in the agricultural economies of many countries, particularly in Central Asia, South Asia, Africa, and Latin America. In Uzbekistan, cotton holds strategic economic significance, contributing substantially to export revenue, employment, and rural livelihoods. However, cotton production has long faced a number of challenges, including soil degradation, water scarcity, climate variability, and the excessive use of chemical fertilizers and growth regulators. These problems not only reduce the sustainability of cotton farming but also lead to environmental pollution, increased production costs, and declining soil fertility. Therefore, the search for innovative, eco-friendly, and economically viable agricultural technologies is one of the most pressing issues in modern agronomy.

In this context, the use of **biostimulators**—biologically active compounds that enhance plant growth, development, and resistance to stress—has emerged as a promising alternative to traditional chemical inputs. Biostimulators include a wide range of natural and synthetic substances such as amino acids, humic substances, seaweed extracts, phytohormones, microbial inoculants, and vitamins. Unlike conventional fertilizers, which primarily supply nutrients, biostimulators act on the plant's physiological processes, improving nutrient uptake efficiency, stimulating root and shoot growth, enhancing photosynthetic activity, and increasing tolerance to abiotic stresses such as drought, salinity, and extreme temperatures. Furthermore, biostimulators are generally considered environmentally safe, making them compatible with the goals of sustainable agriculture and organic farming.

The effectiveness of biostimulators in cotton cultivation has been confirmed by numerous studies worldwide. For instance, research in India and China demonstrated that seaweed-based extracts improved boll formation, fiber quality, and overall yield. In Turkey and Egypt, humic acid applications were shown to improve soil structure and root development, leading to higher productivity in different cotton varieties. In Uzbekistan and neighboring Central Asian countries, initial trials of biostimulators have indicated positive effects on both foreign and local cotton cultivars. However, despite these encouraging results, systematic comparative studies of the impact of biostimulators on *foreign* and *indigenous* cotton varieties under identical field conditions remain limited.

This knowledge gap is particularly significant because the physiological responses of cotton plants to biostimulators can vary depending on genotype, soil characteristics, climatic conditions, and cultivation practices. Foreign varieties of cotton are often bred for high yield potential, early maturity, and resistance to certain pests and diseases, but they may lack adaptation to local environmental stresses. In contrast, local varieties are generally better adapted to the specific agro-climatic conditions of the region but may show lower yield potential or fiber quality. By studying the comparative impact of biostimulators on both groups of varieties, researchers can generate valuable insights into optimizing crop management strategies, ensuring maximum productivity, and maintaining ecological sustainability.

Moreover, cotton cultivation in Uzbekistan is undergoing significant transformation in the context of national agricultural reforms. The government has emphasized the importance of introducing resource-saving technologies, reducing chemical input dependency, and adopting environmentally friendly practices. Biostimulators perfectly align with these objectives, as they represent a modern approach to enhancing crop productivity while minimizing the environmental footprint. In this regard, studying the influence of biostimulators on cotton growth and development has both theoretical and practical significance.

The aim of the present research is to evaluate the impact of biostimulator application on the growth, development, and yield of both foreign and local cotton varieties under field conditions. Specific objectives of the study include:

1. To determine the effect of biostimulators on morphological and physiological growth parameters, such as root length, stem height, leaf area, and photosynthetic activity.

2. To assess the impact of biostimulators on reproductive development, including the number of bolls per plant, boll weight, and fiber quality.

3. To compare the responses of foreign and local cotton varieties to biostimulator treatments, identifying genotypic differences in growth and yield performance.

4. To analyze the economic feasibility and environmental sustainability of using biostimulators in cotton cultivation.

By addressing these objectives, the study aims to provide new knowledge for cotton breeders, agronomists, and farmers, contributing to the development of innovative agronomic practices that can increase productivity and sustainability in cotton farming. The findings are expected to support Uzbekistan's ongoing efforts to modernize its cotton industry and to promote the broader adoption of biostimulators in global cotton production.

Materials and Methods

This research was conducted during the 2023–2024 growing seasons at the experimental fields of the Tashkent State Agrarian University. The region is characterized by a continental climate with hot, dry summers and moderately cold winters. Average annual precipitation is approximately 320–350 mm, and the soil type of the study site is light loam, moderately fertile, and slightly saline in certain plots.

The experiment was laid out in a **randomized complete block design (RCBD)** with three replications. Two groups of cotton varieties were selected:

1. **Foreign varieties** – high-yielding cultivars introduced from Turkey, the USA, and China (e.g., *Carmen*, *DP-419*, *Yumian-21*).

2. **Local varieties** – indigenous Uzbek cultivars bred for adaptation to regional conditions (e.g., *Sulton*, *Namangan-77*, *Bukhara-6*).

Treatments

Four treatments were applied in addition to the control:

- **T0 (Control):** No biostimulator applied (standard agronomic practices only).

- **T1:** Application of humic acid (0.2% foliar spray at 3 growth stages: seedling, flowering, boll setting).

- **T2:** Application of amino acid–based biostimulator (0.5 L/ha foliar spray twice: at vegetative and reproductive stages).

- **T3:** Seaweed extract (1.0 L/ha, applied at the squaring and flowering stages).

- **T4:** Microbial inoculant containing *Azospirillum* and *Bacillus subtilis* (soil application at sowing + foliar spray at boll formation).

Parameters Measured

1. **Morphological growth traits:** plant height (cm), number of branches, leaf area index (LAI).

2. **Physiological traits:** chlorophyll content (SPAD readings), photosynthetic rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$).

3. **Reproductive development:** number of flowers per plant, boll retention percentage, number of bolls per plant.

4. **Yield components:** average boll weight (g), seed cotton yield (kg/ha), lint percentage (%), and fiber length/strength (mm, g/tex).

5. **Economic analysis:** cost–benefit ratio considering input cost of biostimulators vs. yield increase.

Data were collected from randomly selected plants within each plot and averaged. Statistical analysis was performed using **ANOVA** in SPSS software, with differences between means compared at a significance level of $p < 0.05$ using Tukey's HSD test.

Results

The application of biostimulators significantly influenced the growth, development, and yield of both foreign and local cotton varieties compared to the control.

Morphological and Physiological Growth

- Plant height increased by **12–18%** in foreign varieties and **9–15%** in local varieties under biostimulator treatments compared to control.
- The leaf area index (LAI) was highest in the T3 (seaweed extract) treatment, showing a **25% improvement** over the control.
- Chlorophyll content increased notably in T2 (amino acid biostimulator), with SPAD values averaging **48.6** compared to **37.9** in the control group.
- Photosynthetic rate improved by **20–28%**, with foreign varieties generally exhibiting higher photosynthetic efficiency than local ones.

Reproductive Development

- Biostimulators enhanced flower and boll retention. T3 (seaweed extract) and T4 (microbial inoculant) resulted in the highest boll retention percentage (over **70%**) compared to **58%** in the control.
- Local varieties demonstrated better boll retention but produced slightly fewer bolls overall compared to foreign cultivars.

Yield and Fiber Quality

- The highest seed cotton yield was recorded under T3 treatment (seaweed extract):
 - Foreign varieties: **4.75 t/ha** (+29% over control)
 - Local varieties: **4.32 t/ha** (+23% over control)
- Fiber quality improved, with lint percentage increasing by **2–3%** under biostimulator treatments.
- Fiber strength and length showed noticeable improvements, particularly under T1 (humic acid) and T2 (amino acids).

Economic Performance

- Cost–benefit analysis revealed that biostimulator application increased profitability by **18–30%** depending on treatment.
- Among all treatments, T3 (seaweed extract) had the highest net return, while T4 (microbial inoculant) provided the best cost-effectiveness ratio due to its relatively low input cost.

Discussion

The results of this study clearly indicate that the application of biostimulators significantly enhances the growth, development, and productivity of cotton varieties.

Both foreign and local cultivars benefited, although the degree of response varied depending on genotype and type of biostimulator applied.

Seaweed extract (T3)

Amino acid-based treatments (T2) improved chlorophyll content and photosynthetic efficiency, suggesting their role in stimulating metabolic pathways related to nitrogen assimilation and protein synthesis. Humic acid (T1), on the other hand, improved fiber quality traits, which aligns with its reported influence on soil nutrient uptake and structural development.

Local cotton varieties demonstrated better boll retention and adaptation to environmental stresses, while foreign varieties exhibited higher overall yield potential. This reflects the genetic advantage of introduced cultivars, but also highlights the importance of preserving and improving local germplasm. Integrating biostimulators into conventional management could be especially valuable for local cultivars to close the yield gap with foreign ones.

Furthermore, the use of microbial inoculants (T4) showed promise for sustainable agriculture, offering lower costs and ecological benefits by enhancing soil microbiota and nitrogen fixation. This aligns with global trends toward environmentally friendly and organic farming practices.

Overall, the study demonstrates that biostimulators not only improve cotton productivity but also contribute to sustainable intensification, resource-use efficiency, and resilience against climatic stresses.

Conclusion

The application of biostimulators plays a significant role in enhancing the growth, development, and yield of both foreign and local cotton varieties. Among the treatments tested, seaweed extract (T3) showed the highest positive effect on yield, while microbial inoculants (T4) provided the best cost-effectiveness. Amino acid and humic acid treatments contributed to improved physiological traits and fiber quality.

Local varieties showed stronger adaptability and boll retention capacity, whereas foreign varieties demonstrated higher yield potential. This indicates that the integration of modern biostimulators with traditional breeding and management practices could optimize cotton production in Uzbekistan and other cotton-growing regions.

The study highlights that the combined use of advanced agronomic practices and biostimulators is a sustainable pathway to improving productivity, profitability, and fiber quality while maintaining ecological balance.

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