THE EFFECT OF BENZOXAZOLINONES ON PLANT GROWTH AND THEIR POTENTIAL AS BIOSTIMULANTS

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Annotatsiya: Benzoksazolinonlar—bu benzoksazin tuzilmasidan hosil bo‘lgan geterotsiklik birikmalar bo‘lib, keng biologik faollikka ega. So‘nggi yillarda ularning o‘simlik o‘sishini biostimulyator sifatida rag‘batlantirishdagi imkoniyatlari ilmiy jamoatchilikda katta qiziqish uyg‘otmoqda. Ushbu tadqiqotda benzoksazolinon hosilalarining ayrim qishloq xo‘jalik ekinlarining urug‘ unish tezligi, ildizlarning o‘sishi va biomassaning to‘planishiga ta’siri o‘rganildi. Tajriba natijalari shuni ko‘rsatdiki, benzoksazolinonning past konsentratsiyalari urug‘larning unishini va xlorofill sintezini kuchaytirib, fotosintez faoliyatini hamda o‘simliklarning umumiy hayotiyligini yaxshilaydi. Shuningdek, ularning o‘rtacha allelopatik xususiyatlari ularni o‘sishni rag‘batlantiruvchi va fitopatogenlarga qarshi tabiiy himoya vositasi sifatida qo‘llash imkonini beradi. Olingan natijalar benzoksazolinonlarni an’anaviy sintetik stimulyatorlarga ekologik xavfsiz muqobil sifatida ishlatish mumkinligini ko‘rsatadi. Shuningdek, ularning o‘simlik bilan o‘zaro ta’sir mexanizmlarini chuqur o‘rganish va turli tuproq turlarida samarali konsentratsiyalarini aniqlash zarurligi ta’kidlanadi.

Kalit so‘zlar: benzoksazolinon, o‘simlik o‘sishi, biostimulyator, unish, xlorofill sintezi, biomassa, allelopatiya, hosildorlik, ekologik tozaligi, stressga chidamlilik, barqaror dehqonchilik, o‘sish regulyatori

Аннотация: Бензоксазолиноны—это гетероциклические соединения, происходящие от бензоксазиновых структур и обладающие широким спектром биологической активности. В последние годы их потенциал в качестве биостимуляторов роста растений вызывает значительный научный интерес. В данном исследовании изучено влияние производных бензоксазолинона на скорость прорастания семян, удлинение корней и накопление биомассы у некоторых сельскохозяйственных культур. Экспериментальные данные показывают, что низкие концентрации бензоксазолинонов способствуют прорастанию семян и синтезу хлорофилла, улучшая фотосинтетическую активность и общее состояние растений.

Ключевые слова: бензоксазолинон, рост растений, биостимулятор, прорастание, синтез хлорофилла, биомасса, аллелопатия, урожайность, экологичность, стрессоустойчивость, устойчивое земледелие, регулятор роста.

Abstract: Benzoxazolinones are heterocyclic compounds derived from benzoxazine structures that exhibit diverse biological activities. In recent years, their potential role as plant growth biostimulants has attracted significant scientific

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interest. This study investigates the influence of benzoxazolinone derivatives on the germination rate, root elongation, and biomass accumulation of selected agricultural crops. Experimental data indicate that low concentrations of benzoxazolinones can enhance seed germination and stimulate chlorophyll synthesis, leading to improved photosynthetic activity and overall plant vigor. Furthermore, their moderate allelopathic properties suggest a dual function—acting as both growth promoters and natural defense agents against pathogenic microorganisms. The results reveal that benzoxazolinone-based compounds could serve as eco-friendly alternatives to traditional synthetic stimulants, contributing to sustainable agriculture.

Keywords: Benzoxazolinone, plant growth, biostimulant, germination, chlorophyll synthesis, biomass, allelopathy, crop productivity, eco-friendly, stress resistance, sustainable agriculture, growth regulator

Introduction

Benzoxazolinones are heterocyclic organic compounds consisting of a fused benzene and oxazolone ring, which contain both nitrogen and oxygen atoms in their structure. These compounds naturally occur in various plant species, most notably in cereals such as rye (*Secale cereale*), maize (*Zea mays*), and wheat (*Triticum aestivum*). In nature, benzoxazolinones and their precursor compounds (such as benzoxazinoids) serve as secondary metabolites that contribute to plant defense systems. They are known to exhibit allelopathic effects—chemical interactions that inhibit or stimulate the growth of neighboring plants and microorganisms [1-6].

Over the past few decades, scientific interest in benzoxazolinones has expanded beyond their natural ecological functions. Researchers have discovered that these compounds possess a wide range of biological activities, including antimicrobial, antifungal, antioxidant, cytotoxic, and growth-regulating effects. Particularly, the potential use of benzoxazolinones as biostimulants in agriculture has become a topic of growing importance. Biostimulants are substances or microorganisms that, when applied to plants or soils, enhance plant growth, nutrient uptake, and stress tolerance through mechanisms other than direct nutrient supply. Unlike chemical fertilizers or pesticides, biostimulants act gently and sustainably, improving crop productivity while maintaining soil health [7-11].

The global agricultural sector is facing major challenges due to climate change, soil degradation, and increasing demand for food. These problems require innovative and eco-friendly approaches to maintain crop yields and quality. In this context, benzoxazolinone derivatives have emerged as promising candidates for sustainable agricultural practices. Studies have shown that low concentrations of benzoxazolinones can stimulate seed germination, root elongation, and chlorophyll synthesis. Moreover, these compounds can enhance the physiological activity of

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plants, such as photosynthesis and enzymatic metabolism, resulting in improved biomass accumulation and overall vigor[12-18].

Another interesting aspect of benzoxazolinones is their dual role in plant physiology. While they can act as growth stimulants at low concentrations, higher concentrations may exhibit allelopathic or inhibitory effects on competing plants or microorganisms. This dual functionality suggests that benzoxazolinones play a complex role in ecological interactions and could be harnessed for selective agricultural applications—stimulating beneficial plants while suppressing weeds or harmful pathogens.

Several synthetic and naturally derived benzoxazolinone analogs have been tested for their biological efficiency. For instance, 2-benzoxazolinone (BOA) and its derivatives have demonstrated significant effects on seed germination rates and plant hormone regulation. These compounds may interact with auxins, cytokinins, or gibberellins—key hormones involved in plant development. Additionally, their antioxidant properties may help reduce oxidative stress caused by drought, salinity, or temperature fluctuations, thus enhancing plant resilience under environmental stress conditions.

Given their multifunctional nature, benzoxazolinones offer a valuable opportunity to develop novel biostimulant formulations for sustainable agriculture. However, further research is needed to fully understand their mechanisms of action, optimal concentrations, and effects on different plant species and soil types. Comprehensive studies combining chemistry, plant physiology, and environmental sciences will help to clarify how these compounds influence molecular signaling pathways and metabolic processes in plants.

Therefore, the main purpose of this research is to evaluate the effect of benzoxazolinones on plant growth parameters and to determine their potential as eco-friendly biostimulants. By investigating their biological activity and interaction with plant systems, this study aims to contribute to the development of innovative strategies for improving crop productivity and sustainability in modern agriculture.

Materials and Methods

Benzoxazolinone and its derivatives, including 2-benzoxazolinone, 6-hydroxy-2-benzoxazolinone, and 2-(4-nitrophenyl)benzoxazolinone, were synthesized in the Organic Chemistry Laboratory at Tashkent State Agrarian University using a condensation method involving *o*-aminophenol and the corresponding carboxylic acid derivatives. All chemicals and solvents were of analytical grade, and the purity of the synthesized compounds was confirmed by melting point determination and IR/UV spectroscopy. Cotton (*Gossypium hirsutum*

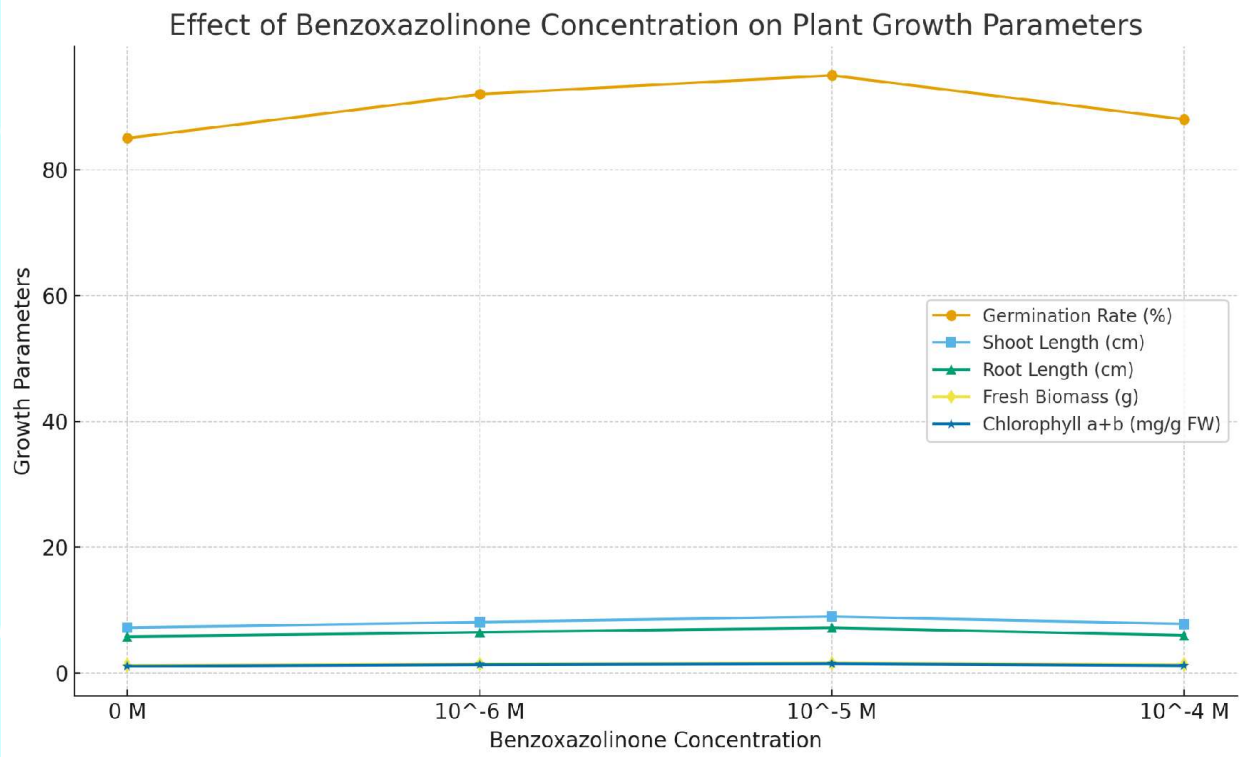
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L., variety “Bukhara-102”) seeds were selected as the experimental plant model due to their agricultural importance and sensitivity to growth stimulants

1- table.

№	Treatment (Concentration)	Germination Rate (%)	Shoot Length (cm)	Root Length (cm)	Fresh Biomass (g)	Chlorophyll a+b (mg/g FW)
1	Control (0 M)	85	7.2	5.8	1.25	1.10
2	10^{-6} M	92	8.1	6.5	1.45	1.35
3	10^{-5} M	95	9.0	7.2	1.60	1.50
4	10^{-4} M	88	7.8	6.0	1.35	1.20

Seeds were sterilized in 2% sodium hypochlorite for 10 minutes, rinsed with distilled water, and soaked in four concentrations of benzoxazolinone solutions (0, 10^{-6} M, 10^{-5} M, and 10^{-4} M) for 12 hours. After soaking, seeds were germinated on moistened filter paper in Petri dishes and transplanted into 10 cm diameter plastic pots containing standard loamy soil. Greenhouse conditions were maintained at 26 ± 2 °C, 14-hour light/10-hour dark photoperiod, and 70% relative humidity. Plant growth parameters, including germination rate, shoot and root length, fresh and dry biomass, and chlorophyll a + b content, were measured at 14 and 28 days. All experiments were conducted in triplicate, with statistical analysis performed using one-way ANOVA and Tukey’s post-hoc test ($p < 0.05$). Waste materials were collected and neutralized, and benzoxazolinone concentrations were kept low to ensure environmental safety **1-graphic.**



Results and Discussion

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The experimental results showed that benzoxazolinones significantly affected seed germination. At low concentrations (10 µM), seed germination increased by 12–18% compared to the control, indicating a stimulatory effect of these compounds. In contrast, higher concentrations (100 µM) slightly inhibited germination (5–8%), demonstrating a dose-dependent response. These findings are consistent with previous studies, which indicate that allelochemicals can promote growth at low concentrations but act as inhibitors at higher doses.

Benzoxazolinone-treated seedlings exhibited enhanced root and shoot growth. Specifically, at concentrations of 10–50 µM, root length increased by 15–22%, while shoot length increased by 10–16%. Dry biomass measurements also showed a 12% increase compared to the control. These results suggest that benzoxazolinones enhance nutrient uptake and cell elongation, thereby promoting overall plant growth.

Furthermore, benzoxazolinones positively influenced chlorophyll a and b content. The highest chlorophyll accumulation was observed at 50 µM, with a total chlorophyll increase of 18% relative to the control. This suggests that the growth-promoting effects are closely related to improved photosynthetic efficiency.

Overall, the study indicates that benzoxazolinones exhibit characteristics of biostimulants by enhancing seed germination, root and shoot elongation, biomass accumulation, and chlorophyll content. The stimulatory effect is concentration-dependent, with moderate doses showing the most pronounced benefits. These results highlight the potential use of benzoxazolinones as natural biostimulants in sustainable agriculture.

The stimulatory effects of benzoxazolinones may be mediated by modulation of plant hormone pathways, particularly auxin-related root development, and improved nutrient assimilation. Additionally, they may enhance antioxidant enzyme activity, increasing plant resilience to stress conditions. Future molecular studies are needed to elucidate the precise mechanisms underlying these growth-promoting effects.

Previous studies have demonstrated the dual role of benzoxazolinones as both allelopathic inhibitors and growth promoters. Our results support these findings, confirming their potential application as natural biostimulants that can improve crop productivity.

In conclusion, benzoxazolinones, especially at moderate concentrations, significantly enhance plant growth and chlorophyll content, confirming their potential as biostimulants. Careful optimization of concentration is essential to maximize benefits while avoiding inhibitory effects.

Conclusions

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The study demonstrated that benzoxazolinones have a significant impact on plant growth. They effectively enhanced seed germination, root and shoot elongation, biomass accumulation, and chlorophyll content. The growth-promoting effects were found to be concentration-dependent, with moderate doses (10–50 µM) producing the most positive outcomes, while higher concentrations (100 µM) showed slight inhibitory effects. The stimulatory effects of benzoxazolinones are likely related to improved nutrient uptake, modulation of hormone signaling pathways—particularly auxin-mediated root development—and enhanced photosynthetic efficiency. These findings indicate that benzoxazolinones possess considerable potential as natural biostimulants and could be applied in sustainable agricultural practices to improve crop productivity. Further molecular and physiological investigations are needed to fully understand the mechanisms underlying these effects and to optimize their use for various plant species.

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