

**BIOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS  
OF AZOTOBACTER CHROOCOCCUM**

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**Аннотация** Azotobacter chroococcum является одним из свободноживущих азотфиксирующих микроорганизмов, имеющих важное агрономическое значение в сельском хозяйстве. Биоудобрения, получаемые на основе данного микроорганизма, оказывают комплексное положительное воздействие на рост и развитие растений и, по сравнению с химическими удобрениями, считаются экологически безопасной и устойчивой альтернативой.

**Ключевые слова:** Azotobacter chroococcum, азотфиксирующий, грамотрицательный, аэробный, микроаэрофильный, гетеротрофный, ауксин, цитокинин, гиббереллин, микрофлора, биогеохимический.

**Annotation.** Azotobacter chroococcum is one of the free-living nitrogen-fixing microorganisms of significant agronomic importance in agriculture. Biofertilizers derived from this microorganism exert a комплексное positive effect on plant growth and development and, compared to chemical fertilizers, are considered an environmentally safe and sustainable alternative.

**Keywords:** Azotobacter chroococcum, nitrogen-fixing, Gram-negative, aerobic, microaerophilic, flagella, heterotroph, auxin, cytokinin, gibberellin, microflora, biofertilizer.

**Introduction.** Currently, soil degradation has become one of the most pressing ecological and agronomic problems worldwide, including in Uzbekistan. Soil degradation is a multifactorial process characterized by the deterioration of physical, chemical, and biological properties of soil. These problems include soil salinization, chemical contamination caused by excessive use of pesticides and toxic chemicals, as well as the deterioration of microbiological and meliorative soil conditions due to the overuse of mineral fertilizers.

In addition, the reduction of organic matter content in soil represents another critical issue. This is mainly associated with monoculture-based farming without crop rotation, insufficient use of organic fertilizers, and incomplete implementation of agro-technical measures. Soil erosion caused by wind and water results in the removal of the fertile topsoil layer, leading to a sharp decline in productivity.

The conservation and rational use of soil resources are essential for sustainable agriculture, food security, and maintaining ecological balance. Therefore, it is necessary to implement scientifically grounded agro-technical and biotechnological measures to reduce degradation processes and restore soil fertility. These measures include the use of biofertilizers, scientifically based crop rotation systems, the development of organic farming, and the introduction of soil-conserving technologies.

Fertilizers are sources of nutrients applied to soil to ensure plant growth, development, and high productivity. Plants absorb water and minerals from the soil during their life cycle, leading to a gradual depletion of soil nutrients. Fertilizers replenish these lost elements and help maintain and enhance soil fertility.

The primary functions of fertilizers include enriching soil with nutrients, supplying essential elements to plants, increasing yield, and improving the quality of agricultural products. In this regard, biological (biofertilizers) and organic fertilizers are distinguished by their environmental safety, positive impact on soil microbiota, and long-term effectiveness. Compared to mineral fertilizers, biofertilizers play a crucial role in preserving and restoring natural soil fertility and enhancing its biological activity.

**Main Part.** *Azotobacter chroococcum* was first discovered in 1901 by the Dutch microbiologist Martinus Willem Beijerinck, marking a significant milestone in the scientific study of free-living nitrogen-fixing bacteria. These microorganisms are capable of independent existence in soil and are distinguished by their ability to fix atmospheric molecular nitrogen through biological processes.

Taxonomically, *Azotobacter chroococcum* belongs to the domain Bacteria, which includes prokaryotic organisms lacking a membrane-bound nucleus. It is classified within the phylum Pseudomonadota (Proteobacteria), a group characterized by metabolically versatile bacteria capable of utilizing diverse energy sources. At the class level, it belongs to Gammaproteobacteria, which includes many ecologically and agriculturally significant microorganisms.

Thus, the discovery and classification of *Azotobacter chroococcum* have provided an important theoretical and practical foundation not only for microbiology but also for understanding and utilizing biological nitrogen fixation in agriculture.

More specifically, it belongs to the class Gammaproteobacteria, family Pseudomonadaceae, genus *Azotobacter*, and species *Azotobacter chroococcum*. This bacterium is a free-living, nitrogen-fixing, Gram-negative, microaerophilic organism that plays a crucial role in enhancing soil fertility.

*Azotobacter chroococcum* fixes atmospheric nitrogen through the enzyme nitrogenase, converting it into ammonium ( $\text{NH}_4^+$ ), a form readily assimilable by plants. Under certain conditions, it produces enzymes such as catalase, peroxidase, and superoxide dismutase, which help neutralize reactive oxygen species. During nitrogen

fixation, a water-soluble dark brown pigment-melanin is produced, which protects nitrogenase from oxygen damage.

Morphologically, the bacterium is typically large and oval-shaped, often producing a mucilaginous layer. It is motile due to the presence of flagella and usually occurs singly or in pairs. Colonies are smooth and glossy, and the organism does not form spores.

Nutritionally, it is a heterotrophic (chemoorganotrophic) organism that utilizes organic compounds, particularly carbohydrates, as energy sources. It grows optimally in neutral conditions, though it can tolerate slightly acidic or alkaline environments. The optimal growth temperature is 25–30 °C, with a pH range of 6.5–7.5. It is commonly cultured in specialized media such as Ashby's medium.

*Azotobacter chroococcum* is predominantly found in soils rich in organic matter (humus), especially in fertile soils such as chernozems. It is most abundant in moist environments during spring and summer and in cultivated agricultural fields.

In agriculture, *Azotobacter chroococcum* is widely used as a biofertilizer. It enhances plant growth by fixing atmospheric nitrogen and producing phytohormones such as auxins, cytokinins, and gibberellins, thereby increasing crop yield. Additionally, it improves soil microflora and contributes to soil health.

Compared to chemical fertilizers, it is more beneficial for plants, soil, and the environment. It can solubilize phosphorus and other minerals; certain strains exhibit phosphate-solubilizing activity, making elements such as phosphorus, iron, and zinc more available to plants.

Furthermore, some strains exhibit antagonistic activity against plant pathogens, including fungi such as *Fusarium*, *Pythium*, and *Rhizoctonia*, providing natural biological protection. It is widely applied in organic farming systems, helps reduce soil chemical pollution, restores soil structure, and enhances fertility.

Through bioreactor-based cultivation, commercial biopreparations can be produced on an industrial scale. These are used for soil amelioration and reducing environmental contamination.

**Conclusion.** *Azotobacter chroococcum* is a free-living nitrogen-fixing microorganism of high agronomic importance in agriculture. Biofertilizers based on this bacterium provide комплексное positive effects on plant growth and development and represent an environmentally safe and sustainable alternative to chemical fertilizers.

This microorganism converts atmospheric nitrogen into plant-available forms and synthesizes plant growth-promoting substances such as auxins, cytokinins, and gibberellins. As a result, root development is enhanced, vegetative growth is stimulated, and overall crop productivity increases.

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