

# BIOLOGICAL SCIENCES

## MYCOBIOTA OF COTTON (*GOSSYPIUM HIRSUTUM* L.) CULTIVATED IN THE ARAN KARABAKH REGION (AZERBAIJAN): TAXONOMIC DIVERSITY AND ECOLOGOTROPHIC STRUCTURE

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### Abstract

Cotton (*Gossypium hirsutum* L.) represents a key industrial crop cultivated in the semi-arid lowlands of Azerbaijan. The Aran Karabakh region is characterized by intensive irrigation agriculture, elevated summer temperatures, and periodically saline soils, all of which influence plant–microorganism interactions. The present study investigates the composition and ecological structure of microscopic fungi associated with cotton plants grown under field conditions in this region. Fungal isolates were recovered from roots, stems, leaves, and bolls using classical culture-based techniques followed by morphological identification. The obtained results demonstrated that the fungal assemblage was dominated by Ascomycetous taxa, particularly species of *Fusarium*, *Alternaria*, *Aspergillus*, *Cladosporium*, and *Penicillium*. Ecological assessment revealed a predominance of pathogenic and opportunistic saprotrophic forms, whereas endophytic representatives occurred less frequently. The findings contribute to understanding the fungal ecology of cotton agroecosystems in Azerbaijan and emphasize the necessity of phytosanitary surveillance in intensively cultivated arid landscapes.

**Keywords:** cotton; fungal diversity; agroecosystem; phytopathogens; Aran Karabakh; micromycetes

### 1. Introduction

Cotton is among the most economically valuable fiber crops worldwide and plays a strategic role in the agricultural sector of many semi-arid countries. *Gossypium hirsutum* L., the most widely cultivated species, accounts for the majority of global cotton production (FAO, 2023). In Azerbaijan, cotton cultivation is concentrated primarily in the lowland zones, including the Aran Karabakh territory, where irrigation compensates for limited precipitation.

Agroecosystems located in arid and semi-arid environments create favorable conditions for the development of diverse fungal communities. Soil temperature fluctuations, water stress, and anthropogenic agricultural practices significantly affect the composition of plant-associated microbiota (Compant et al., 2021). Cotton plants are particularly vulnerable to fungal infections that can impair root systems, vascular tissues, and reproductive organs.

Numerous studies report that *Fusarium* spp. are major causal agents of wilt diseases in cotton, leading to considerable yield reduction (Zhang et al., 2019; Wang et al., 2022). *Alternaria* and *Cladosporium* species frequently colonize aerial plant parts, while *Aspergillus* and *Penicillium* species are often isolated from seeds and stored plant material. Some of these fungi are capable of producing secondary metabolites with toxicological significance (Battilani et al., 2016).

Despite the recognized importance of cotton phytopathology globally, region-specific data concerning fungal communities associated with cotton in Azerbaijan remain insufficient. Therefore, this study aims to characterize the taxonomic composition and ecological-functional structure of fungi colonizing cotton plants cultivated in the Aran Karabakh lowland.

### 2. Materials and Methods

#### 2.1 Study Area

The Aran Karabakh lowland is situated in the central part of Azerbaijan and represents one of the principal agricultural zones of the country. The region forms part of the Kura–Araz lowland and is characterized by flat to slightly undulating relief. It borders the foothill areas of the Lesser Caucasus and includes extensive irrigated agricultural lands where cotton cultivation is widely practiced.

The total area of the Aran economic region exceeds 21,000 square kilometers and plays a strategic role in Azerbaijan's agricultural production. Unlike mountainous territories, the landscape here is predominantly plain, with elevations generally ranging between 0 and 200 meters above sea level. The geomorphological structure consists mainly of alluvial and proluvial deposits formed by the Kura and Araz river systems. Sedimentary layers of Quaternary origin dominate the geological composition of the territory.

The climate of the Aran Karabakh region is semi-arid and dry subtropical. Summers are long, hot, and dry, with average July temperatures ranging between 25°C and 30°C, often exceeding these values during peak periods. Winters are relatively mild, with average January temperatures between 0°C and 5°C. Annual precipitation is limited, typically ranging from 250 to 350 mm, which makes irrigation essential for sustainable crop production.

Soils in the region are predominantly grey-brown (sierozem) and alluvial-meadow types. In certain areas, moderate soil salinity is observed due to intensive irrigation and high evaporation rates. The presence of carbonate-rich and clayey substrates influences water retention capacity and microbial activity in the soil profile. These edaphic conditions significantly affect

the composition and distribution of fungal communities associated with cultivated crops.

The hydrographic network is represented primarily by irrigation canals connected to the Kura and Araz rivers. Artificial reservoirs and drainage systems play a critical role in maintaining agricultural productivity. Continuous irrigation, combined with high summer temperatures, creates favorable microenvironmental conditions for the development and persistence of soil-borne and aerial fungal species in cotton agroecosystems.

## 2.2 Plant Material

Three cotton (*Gossypium hirsutum* L.) fields widely cultivated in the Aran region were selected as study sites. Plant samples were collected from tree natural fields during the vegetative growth stage. Healthy and visibly stressed cotton leaves, stems, and bolls were sampled to assess fungal diversity under different physiological conditions.

## 2.3 Fungal Isolation and Identification

Fungal isolation was conducted using conventional mycological methods. Healthy and stressed leaves, stems, and bolls of cotton were aseptically placed on YGC (Yeast Extract-Glucose-Chloramphenicol) and DG18 (Dichloran-Glycerol) agar media and incubated at 25–27 °C. Colony development was monitored daily, and pure cultures were obtained through subculturing.

Identification of fungal isolates was based on macroscopic characteristics (colony shape, color, growth rate) and microscopic structures (conidia, hyphae, sporulation structures) using light microscopy. Taxonomic determination was carried out according to international mycological keys and reference databases.

During fungal cultivation in the laboratory, various equipment and materials were used, including autoclaves, magnetic stirrers, sterile flasks or Pyrex bottles, Petri dishes, and precise weighing scales. The choice of nutrient medium depends on the optimal growth conditions for each fungal species. Ready-made YGC and DG18 agar media were used for cultivation.

To prepare the nutrient media, 22.5 g of agar was accurately weighed per 1 L of distilled water, thoroughly mixed on a magnetic stirrer, and sterilized by autoclaving. Sterile media were poured into Petri dishes under UV-sterile conditions. Samples were handled aseptically with tweezers and placed into the dishes. Control plates were included to monitor any external contamination.

The plates were incubated at 25–27 °C, and full fungal development was usually observed within five days. The incubator temperature was measured and recorded daily to ensure stable growth conditions. Fungal development was monitored starting from the third day, and developed colonies were transferred to a clean environment for species identification.

Colonies were examined on slides using Gram staining under a microscope to determine species identity. For reference, databases of the International Association of Mycology and the CBC collection were used.

It is possible to determine whether the growth and development of mushroom species differ by the Growth Factor. The Growth Factor is based on a special formula:  $D$  is the diameter of the colony (measured in millimeters),  $H$  is the vertical size (height) of the colony,  $S$  is the density indicator of the colony (evaluated on a scale from 1 to 5), and  $T$  is the cultivation period (in days).

The systematic classification of plant species and their distribution frequency was calculated using the following method:

$$N = n / s$$

where  $N$  represents the frequency of occurrence (units per hectare),  $n$  is the number of individuals of a specific medicinal plant species observed in a given area, and  $S$  is the total area studied (in hectares).

The occurrence frequency of fungal species in the samples and the prevalence of diseases caused by pathogenic microorganisms were determined using the formula:

$$P = (n / N) \times 100$$

where  $P$  is the detection frequency of fungal species in the samples or the prevalence of pathogen-induced diseases (in %),  $n$  is the number of specific fungal samples (i.e., plants exhibiting disease symptoms), and  $N$  is the total number of plant samples examined.

All experiments were repeated at least three times, and the resulting data were analyzed using statistical methods. Only results meeting the following criterion were considered reliable and included in the dissertation:

$$m/M = P \leq 0.05$$

where  $M$  is the mean value,  $m$  is the standard deviation, and  $P$  is the probability level estimated using Student's  $t$ -test

## 2.4 Statistical Analysis

The frequency of fungal occurrence and plant colonization was calculated using standard ecological indices. All experiments were conducted in triplicate, and statistical reliability was assessed using Student's  $t$ -test, with significance accepted at  $P \leq 0.05$ .

## 3. Results

A total of more than 18 species of microscopic fungi were isolated from cotton plants. The majority of identified taxa belonged to the phylum Ascomycota (approximately 70%), while representatives of Mucorales (Zygomycota) accounted for about 30%.

The most frequently detected genera were *Fusarium*, *Alternaria*, *Aspergillus*, *Penicillium*, and *Cladosporium*. *Fusarium* species were predominantly isolated from root and stem tissues and were associated with vascular discoloration and wilting symptoms. *Alternaria* and *Cladosporium* were mainly detected on leaf surfaces, particularly in senescent tissues.

Saprotrophic fungi were commonly isolated from damaged bolls and post-harvest residues, whereas pathogenic species were more frequent in stressed plants exposed to high temperature and water deficit conditions.

## 4. Discussion

The predominance of Ascomycota corresponds with global observations of cotton-associated fungal communities (Zhang et al., 2019). *Fusarium* species are

widely recognized as destructive soil-borne pathogens capable of surviving in crop residues and soil for extended periods.

High summer temperatures and irrigation-dependent agriculture in the Aran Karabakh region likely promote fungal persistence and dispersal. Similar ecological patterns have been described in semi-arid cotton-growing systems (Wang et al., 2022).

Saprotrophic fungi contribute to organic matter decomposition within agroecosystems, whereas pathogenic forms pose direct risks to plant productivity. The relatively lower presence of endophytes may reflect environmental stress factors limiting mutualistic associations.

Overall, the fungal community structure appears to be shaped by climatic stress, soil properties, and intensive cultivation practices.

### 5. Conclusions

Cotton plants cultivated in the Aran Karabakh region host a diverse and ecologically heterogeneous mycobiota dominated by Ascomycetous fungi. Pathogenic species, particularly *Fusarium* and *Alternaria*, prevail in stressed plant tissues, while saprotrophic fungi colonize damaged and senescent organs.

The obtained results emphasize the importance of continuous phytopathological monitoring and integrated disease management strategies in cotton agroecosystems. Regular mycological control may contribute to improved yield stability, fiber quality, and environmental safety in the region.

### References

1. Battilani, P., Toscano, P., Van der Fels-Klerx, H. J., et al. (2016). Aflatoxin B1 contamination in maize in Europe increases due to climate change. *Scientific Reports*, 6, 24328.
2. Compant, S., Samad, A., Faist, H., & Sessitsch, A. (2021). A review on the plant microbiome: ecology, functions and emerging trends. *Microorganisms*, 9(3), 607.
3. FAO (2023). FAOSTAT Statistical Database. Food and Agriculture Organization of the United Nations.
4. Khan, M., Ullah, A., Ali, S., et al. (2020). Impact of climate variability on cotton production. *Agronomy*, 10(7), 1001.
5. Leslie, J. F., & Summerell, B. A. (2006). *The Fusarium Laboratory Manual*. Blackwell Publishing.
6. Li, X., Zhang, Y., Ding, C., et al. (2020). Soil fungal communities in cotton fields under long-term monoculture. *Applied Soil Ecology*, 150, 103443.
7. Munkvold, G. P. (2017). *Fusarium* species and their associated mycotoxins. *Plant Disease*, 101(4), 541–552.
8. Porras-Alfaro, A., & Bayman, P. (2011). Hidden fungi, emergent properties: endophytes. *Annual Review of Phytopathology*, 49, 291–315.
9. Wang, Y., Zhang, J., Liu, H., et al. (2022). Diversity and pathogenicity of *Fusarium* species associated with cotton. *Plant Disease*, 106(4), 1123–1132.
10. Zhang, L., Yang, X., Li, J., et al. (2019). Fungal community structure in cotton rhizosphere. *Applied Soil Ecology*, 140, 35–44.
11. Zhou, J., Ning, D. (2017). Stochastic community assembly in microbial ecology. *mBio*, 8(3), e00344-Mammadova F. (2025). Study of Microscopic Fungi on Medicinal Plants Growing in the Kedabay Region. *Bulletin of Science and Practice*, 11(11), 37–47. <https://doi.org/10.33619/2414-2948/120/04>
12. Sabuka, N., & Fidan, M. (2022). SYSTEMATIC (BY TYPE) DETERMINATION OF MUSHROOMS IN WATERMELON AND PUMPKIN PLANTS GROWING IN AGSTAFI REGION. *EDITORIAL BOARD*, 73.
13. Mammadova, F. (2024). PATHOGENIC FUNGI LIVING ON PLANTS CULTURALLY CULTIVATED IN AZERBAIJAN. *German International Journal of Modern Science/Deutsche Internationale Zeitschrift für Zeitgenössische Wissenschaft*, (91).
14. Safaraliyeva, E. M., Mammadova, F. R., Rzaeva, A., & Aliyeva, G. R. (2019). Change of species composition of fungi, spread in various cenoses in the conditions of Azerbaijan. *International Journal of Current Research and Academic Review*, 7(5), 5–8. <https://doi.org/10.20546/ijcrar.2019.705.002>
15. Aliyeva, G., Mamedova, F., & Bakhshaliyeva, K. (2020). Изменение видового состава грибов, распространенных на различных ценозах в условиях Азербайджана. *Современная Наука: Актуальные Проблемы Теории и Практики. Естественные и технические науки*, 2, 52–55. Moskva.
16. Bakhshaliyeva, K. F., Namazov, N. R., Hasanova, A. R., Mammadova, F. R., & Muradov, P. Z. (2020). Assessment of the prospects of studying and using mushrooms of Azerbaijan as effective producers of biologically active substances. *Periódico Tchê Química*, 17(34), 403–411. [https://doi.org/10.52571/PTQ.v17.n34.2020.427\\_P34\\_pgs\\_403\\_411.pdf](https://doi.org/10.52571/PTQ.v17.n34.2020.427_P34_pgs_403_411.pdf).
17. Mammadova, F. (2025). Study of microscopic fungi on medicinal plants distributing in Gadabay region. *Bulletin of Science and Practice*, 11(11), 37–47. <https://doi.org/10.33619/2414-2948/120/04>
18. Еюбов, Б. Б., Меджнунова, А. А., Гахраманова, Ф. Х., Алиева, Ф. А., & Мамедова, Ф. Р. (2009). Способность патогенных грибов выделять гидролитические ферменты. *Вестник МГОУ, серия*
19. Jafarzadeh, S., & Iskender, E. (2024). Determination of Fungal Pathogens in the Species of Genus of *Pyrus* L. as Biotic Factor in Greater Caucasus, Azerbaijan. *Biosciences Biotechnology Research Asia*, 21(3), 1037.
20. Искендер, Э. О., Велиева, Л. И., Аббасов, Р. М., Багирова, Г. Г., & Джафарзаде, С. А. (2015). Редкие растения флоры Азербайджана в озеленении г. Баку. *Новые и нетрадиционные растения и перспективы их использования*, (11), 47–48.
21. Jafarzadeh, S., kizi Amirova, M. F., Bakhshaliyeva, K., Iskender, E., Mammadova, B., Muradova, S., & Muradov, P. (2025). Conservation and propagation of *Pyrus* L. species in the greater Caucasus: integrating biodiversity strategies with “Green Economy” principles. *ARPHA Preprints*, 6, e163932.

22. Elshad, G., & Humira, G. (2021). Research and protection of the coastal psammophyte-desert vegetation of Absheron National Park. *Бюллетень науки и практики*, 7(1), 49-54.
23. Gurbanov, E. M., & Huseynova, H. Z. (2021). Classification and productivity of winter pastures in Lankaran-Mugan botanical-geographical region. *Journal of Life Sciences & Biomedicine*, 3(76), 84-90.
24. GURBANOV, E., HUSEYNOVA, H., MAMMADOVA, Z., & RAZAEVA, A. ENDEMIC PLANTS OF THE CASPIAN COAST FLORA (IN AZERBAIJANI TERRITORY). *GERMAN INTERNATIONAL JOURNAL OF MODERN SCIENCE Учредители: Artmedia24*, (91), 6-8.
25. Vilayet, A., & Boyukkhanim, J. (2024). THE ACTIVITY OF PEROXIDASE AND SUPEROXIDE DISMUTASE IN PLANT SEEDLINGS UNDER SALT STRESS. *Acta Botanica Caucasica*, 3(2), 21-29.
26. Amrahov, N., Hasanova, U., Aliyeva, G., Aghazada, G., Mammadova, R., Alizade, S., Gakhramanova, Z., Hasanova, S., Mukhtarova, N., & Mammadov, Z. (2025). Effect of kinetin-graphene oxide nanoensemble on the development and antioxidant system of cotton. *Acta Botanica Caucasica*, 4(1), 55-65. <https://doi.org/10.30546/abc.2025.4.1.612>
27. Aliyev, E., Amrahov, N., Khudayev, F., Mammadov, Z., Hasanova, S., Valiyev, A., & Hasanova, U. (2025). Effects of IAA and IAA-graphene oxide nanoensemble on drought stress in durum wheat (*Triticum durum*). *Acta Botanica Caucasica*, 4(3), 43-51. <https://doi.org/10.30546/abc.2025.0022>