

RESEARCH PAPER

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The main diseases of cucumber (*Cucumis sativus* L.) grown in the Republic of Azerbaijan and the species composition of pathogens of these diseases

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ABSTRACT

Cucumis sativus L. plant cultivated in open and covered conditions in the Republic of Azerbaijan, was studied for phytopathogenic fungal biota. It has been determined that a total of 15 fungal species are involved in the formation of the phytopathogenic mycobiota of cucumber plants. Although more than half of the recorded fungi showed phytopathogenic properties in both conditions, overall, covered conditions were more favorable for the development of fungal. The reason for this is that the parameters that are important for plants in covered conditions are favorable for fungi, and these parameters are relatively more stable in covered conditions. The species involved in the formation of the phytopathogenic mycobiota of cucumber plants had a certain specificity in terms of the prevalence of the diseases they caused, the forms of observation, and the effect of the effects. Although some of them cause diseases with the same name and have similar symptoms, it has been determined that each disease also has symptoms that arise from the biological characteristics of the fungus itself.

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INTRODUCTION

In modern times, providing people with plant-based food products is one of the important issues that any country plans to solve. The importance of this issue is necessitated by the increasing world population within the fixed territory of the Earth, the increasing burden of anthropogenic impact on the environment, the decrease in useful land areas used by people for various purposes, the expansion of urbanization, and other processes. Thus, according to UNO forecasts, the world population is expected to reach 10.3 billion in 2084, which allows us to note a 1.5-fold increase (Choreziak *et al.*, 2025; Australian Government, 2024) in population compared to 2024. This, in turn, will inevitably create additional problems in meeting the growing population's demand for various substances, primarily food. Therefore, conducting research aimed at solving these problems is currently one of the most relevant.

It should be noted that, against the background of the above, meeting people's needs for nutrients, especially those of plant origin with relatively high biological value, is one of the tasks that is in the focus of special attention (Choreziak *et al.*, 2025). Research conducted to address these issues mainly covers two areas. The first direction is that it includes increasing the productivity of plants used for this purpose, eliminating conditions that cause crop losses, implementing cultivation with more efficient technologies, and so on. The second direction involves the creation of new varieties that are productive, disease-resistant, capable of growing under stressful conditions, and have other characteristics. Sometimes these two directions are carried out in a mixed manner.

Regardless of this, the purpose of conducted research in both directions is to improve both the quantity and quality of the products produced.

As in a number of countries around the world, the agricultural sector plays an important role in the economy of the Republic of Azerbaijan, so cereals, vegetables, melons, fruits, etc. are cultivated

throughout the country, and hundreds of thousands of tons of crops are harvested every year (Babayeva *et al.*, 2025). For example, about 50% of the country's 86.6 thousand km² area is occupied by usable land in which, according to data from 2024, 1,685,734.0 tons of wheat, 22,206.6 tons of legumes, 490,558.2 tons of melons, 1,838,903.3 tons of vegetables, and 1,317,868.2 tons of fruit were grown (State Statistical Committee of Azerbaijan, 2025). Despite this, the volume of products produced does not fully meet the needs of the country's population even today, and therefore the issue of increasing productivity and reducing crop losses is of greater importance for the Republic of Azerbaijan.

Vegetables are among the plants widely cultivated in the Republic of Azerbaijan, as the cultivation of vegetable plants such as tomatoes, cucumbers, eggplants, etc. is found in all regions of the country (Huseynov *et al.*, 2020). Sometimes the expected yield cannot be obtained from these plants, and one of the reasons for this is the result of diseases caused by various organisms, primarily fungi (Bakhshaliyeva *et al.*, 2023; Muradov *et al.*, 2019). To prevent this, it is important to determine the species composition of these pathogens.

Therefore, the purpose of the presented work is to determine the species composition of diseases and their causative agents observed in cucumber plants cultivated under covered conditions in Azerbaijan.

MATERIALS AND METHODS

The research was conducted in the greenhouses of the Vegetable Growing Research Institute of the Ministry of Agriculture of the Republic of Azerbaijan. Samples for the study were taken from the vegetative and generative organs of the cucumber plant, which are suspected to be diseased, according to known methods (Chauhan and Jindal, 2020; Maheshwari, 2016). The isolation of fungi from the samples was carried out in the following 3 stages:

1. Microscopic examination of the samples taken. During the implementation of these works were used

standard methods and approaches [Mat] which used in similar works and the control of the process was performed with an OMAX 40X-2500X LED Digital Lab Trinocular Compound Microscope with USB Camera microscope

2. Placing the infected part of the plant in a humidity chamber for 2-3 days and re-microscoping it;

3. Transferring the suspected diseased part to agarized standard nutrient media (agarized malt juice, Saburo agar, etc.), obtaining a pure culture and microscopically examining it, and identifying the pathogen.

Identification of fungi grown in pure culture and the diseases they cause was carried out using classical mycological approaches, based on known determinants (Balaji, 2018; Li *et al.*, 2023; Satton *et al.*, 2001).

The prevalence rate of diseases (P) was calculated according to the formula $P=(n/N)\times 100$, where n is the number of samples in which the disease was detected, and N is the total number of samples.

When obtaining quantitative results, the repetition of the experiments was at least 4 and the results were statistically processed (Lebedev and Uraev, 2021).

RESULTS AND DISCUSSION

As a result of the analysis of samples taken from cucumber plants cultivated under covered condition, it was determined that the pathogenic mycobiota of the plant includes 15 fungal species (*Alternata alternata*, *A. cucumerina*, *A. solani*, *Ascochyta cucumis*, *Botrytis cinerea*, *Cladosporium fulvum*, *Colletotrichum orbiculare*, *Erysiphe cichoracearum*, *Fusarium equiseti*, *F. solani*, *Rhizoctonia solani*, *Sphaerotheca fuliginea*, *Sclerotinia sclerotiorum*, *Verticillium albarthum* and *V. dahliae*) belonging to 11 genera (*Alternaria*, *Ascochyta*, *Botrytis*, *Cladosporium*, *Colletotrichum*, *Erysiphe*, *Fusarium*, *Rhizoctonia*, *Sphaerotheca*, *Sclerotinia* and *Verticillium*), which differ from each other in terms of

their ecotrophic relationships, ecophysiological indicators, etc. characteristics. Although all of the recorded fungi belong to the ascomycetes, one species of basidiomycetes (*Rh. solani*) is also found among the phytopathogenic fungi. Of the 14 species of ascomycetes, 3 (*E. cichoracearum*, *S. fuliginea* vs *Sc. sclerotiorum*) are teleomorphs, and the rest are anamorphs, meaning that 78.6% of the registered ascomycetes are anamorphs.

Anamorphs include phytopathogens that are mainly hemibiotrophs and necrotrophs, which also have high adaptive capabilities. This is reflected in the fact that they do not experience any particular difficulty in meeting their nutritional needs. Thus, teleomorphs, especially their true biotroph species (in our case, *E. cichoracearum*, *S. fuliginea*), although they cause disease, are not considered as dangerous as anamorphs.

As mentioned, fungi are divided into three groups based on the way they infect plants: biotrophs, hemibiotrophs, and necrotrophs (Priyashantha *et al.*, 2023). According to the mentioned classification, when characterizing the 15 species of fungi recorded on cucumber plants during the research, 2 (*E. cichoracearum* and *S. fuliginea*) of them belong to biotrophs, 6 (*Fusarium equiseti*, *F. solani*, *Rhizoctonia solani*, *Sc. sclerotiorum*, *Verticillium albarthum* and *V. dahliae*) to hemibiotrophs, and the remaining 7 (*Alternata alternata*, *A. cucumerina*, *A. solani*, *Ascochyta cucumis*, *Botrytis cinerea*, *Cladosporium fulvum* and *Colletotrichum orbiculare*) to necrotrophs. Regarding the diseases caused by the registered fungi in cucumbers, the study found that the diseases they cause differ in a number of characteristics. This can also be confirmed by the information provided regarding the general characteristics of the symptoms observed in plants of diseases caused by the mentioned fungi.

Powdery mildew disease

Fungal species such as *E. cichoracearum* and *S. fuliginea*, which belong to biotrophs, are involved in the occurrence of this disease in cucumber plants. The

disease caused by these fungi, which are characterized as ectoparasites, is mainly observed on the leaves of the plant (Fig. 1A). As seen, the disease manifests itself as grayish patches on the upper surface of the leaves. Powdery mildew pathogens have both a sack and a conidial stage, with the conidial stage where the conidia of the fungus *E. cichoracearum* are in the form of chains (Fig. 1B). For the disease to develop, it is sufficient for the air humidity to be at least 50% and the temperature to reach 18°C.

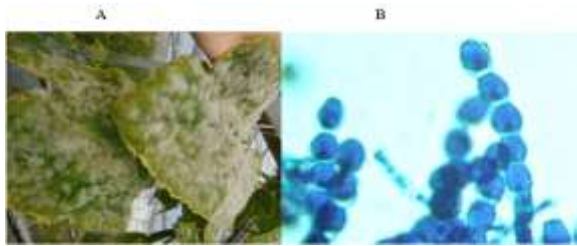


Fig. 1. Microscopic view of powdery mildew disease (A) caused by the fungus *E. cichoracearum* on cucumber plants, and the conidia it produces (B)

The disease is mainly caused by spores that overwinter in the soil which fall on the plant mainly during irrigation, especially drip irrigation. Observations conducted during the research revealed that the disease caused by the fungus occurs both in open and closed conditions, it was also found that higher infection rates occur in field conditions. Thus, while the prevalence degree of the disease was 2.7% in the closed conditions, this indicator was 5.1% in field conditions.

White rot

It has been determined that this disease in cucumber plants is caused by the fungus *Sclerotinia sclerotiorum*, which belongs to the teleomorphs. The disease is observed in the above-ground part of the plant, that is, on the stem, leaves, and fruit of the plant. The observed form of the disease consists of the accumulation of mycelium, or more precisely, sclerotia, which are modified forms of mycelium, in a certain area of the plant. Fungal spores infect the plant through the apices of its leaves, damaged areas of the stem, and the stamens of the flower, and their visual appearance is relatively different (Fig. 2).

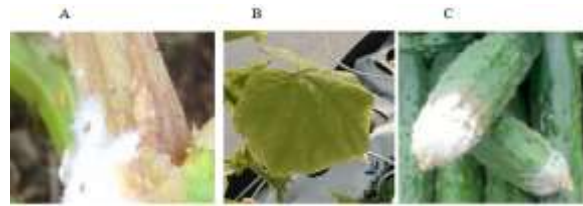


Fig. 2. General view of the disease caused by the fungus *Sclerotinia sclerotiorum* on the trunk (A), leaves (B) and fruit (C) of cucumber plants

Although observations have shown that the fungal disease occurs both in open and covered conditions, it has been determined that the spread of the disease is characterized by a relatively high infection rate in covered conditions. Thus, while the prevalence of the disease in field condition is 1.7%, it is 3.5% in covered conditions. More precisely, white rot disease can be considered one of the more dangerous diseases in covered conditions.

It can be noted that the fungus *S. sclerotiorum* is a universal pathogen (Hossain *et al.*, 2023), as the diseases it causes are found in vegetable plants such as tomatoes, sunflowers, cabbage, eggplant, peppers, etc., as well as in many feed and medicinal plants, and sometimes the yield loss as a result of the disease can be up to 100% (Hossain *et al.*, 2025).

Spottiness

This name refers to a disease caused by several fungi separately, but which is generally the same in terms of the observed form (Fig. 3). For this reason, the name of the causative agent is used in naming this disease, and this approach was also used in our studies. Thus, during the course of research, the following forms of spotting disease were encountered.

It has been determined that fungi such as *Alternata alternata*, *A. cucumerina*, and *A. solani* are involved in the occurrence of alternariosis (black or brown spot) disease, and the diseases caused by these fungi consist mainly of black or dark brown spots observed on both sides of the plant's leaves. The disease is mainly observed on the lower leaves of the plant and, although it initially appears as small spots, it gradually grows and the leaves turn yellow and dry.

Diseases caused by fungi belonging to the genus *Alternaria* are observed in both conditions of cucumber cultivation, and the prevalence rate is characterized by similar indicators for both conditions - $2.3 \pm 0.1\%$.



Fig. 3. General appearance of ascochyta (A), cladosporiosis (B), alternariosis (C) and gray rot diseases in cucumber plants

The fungus *Asc. cucumis* is also involved in the development of the disease of the same name, which is also called ascochytirosis. This fungus belongs to mesophiles and the temperature indicator favorable for its development is $28-30^{\circ}\text{C}$. Since humidity is also an important factor in the development of this disease, it can spread more widely in mainly covered conditions, which has been confirmed in our studies. Thus, while the overall infection rate of fungal diseases is 2.7% , this figure is 3 times lower in field conditions.

Spot disease is also caused by the fungus *Cladosporium fulvum*, and studies have found the disease to occur in both open and covered conditions. The symptom observed in the disease caused by the fungus consists of separate dark-colored spots that vary in size.

Gray rot

This disease is caused by the fungus *Botrytis cinerea*, which is found in both the vegetative and generative organs of the plant. The disease caused by the fungus is observed during the vegetation period of the plant, as well as during storage, and the fungus enters the plant through natural and mechanical damage to the plant. The name of the disease is related to the color of the irregularly shaped spots that appear on the plant. High humidity is one of the factors that promotes the spread of the disease in the plant. Although powdery mildew is

considered one of the main diseases of cucumbers, its prevalence is not very high. Its prevalence in open and covered conditions is $2.1 \pm 0.3\%$.

Anthracnose The causative agent of the disease is the fungus *Colletotrichum orbiculare*, which causes the disease in both vegetative (Fig. 4B) and generative (Fig. 4A) organs of the plant. The observed form of this disease is spotting, which first manifests itself as a wet area on a certain part of the plant's leaves. Over time, a small, pale yellow, circular spot forms in that area, darkens, and its diameter can reach several centimeters.



Fig. 4. General appearance of the disease caused by the fungus *C. orbiculare* on the fruit (A) and leaves (B) of a cucumber plant

Although the disease caused by the fungus is found in both open and covered conditions, the disease it causes is more dangerous in greenhouses, which is due to the high humidity in those conditions. High humidity is also more favorable for the development of the pathogen.

Wilt disease

During the course of research, two forms of this disease have been encountered, the first of which is fusariosis wilt, and the second is verticilliosis wilt (Fig. 5). *Fusarium equiseti* and *F. solani* are involved in the pathogenesis of fusarium wilt, while other types of wilt are caused by fungi such as *Verticillium albarthum* and *V. dahliae*. The difference between these two diseases from others is that these fungi affect the general processes occurring in the plant, causing the plant to wilt and then dry out.

Although wilt diseases occur in both open and covered conditions, covered conditions are

considered more favorable for the development of both diseases.



Fig. 5. General appearance of fusariosis (A) and verticilliosis (B) diseases in cucumber plants

Root rot

During the course of research, it became clear that the fungus *Rhizoctonia solani* is the causative agent of this disease, which was also found in the roots of the plant. Although the fungus infects the roots of the plant, its negative effects are also observed in the aboveground parts of the plant (Fig. 6).



Fig. 6. General appearance of the disease caused by the fungus *Rh. solani* in various organs of the cucumber plant

CONCLUSION

Thus, as a result of the conducted research, fungal diseases of cucumber plants cultivated in open and covered conditions in the Republic of Azerbaijan were analyzed and it became clear that the overall phytopathogenic mycobiota of the plant includes 15 fungal species. Although most of the recorded fungi cause disease in both conditions, covered conditions are considered relatively favorable for fungal diseases. This is one of the points that draws attention to a deeper understanding of the ecological aspects of plant-fungus relationships and is useful when developing measures to combat diseases caused by fungi. On the other hand, the results obtained are interesting in that they also serve to expand our understanding of how fungal diseases occur in specific ecological conditions.

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