Plant & Fungal Research (2025) 8 (2): 28-38
https://doi.org/10.30546/2664-5297.2025.8.2.1023
ISSN 2617-8001 (print), ISSN 2664-5297 (online)

Revision of the genus *Cercospora* Fresen. ex Fuckel in the fungarium (BAK) of Azerbaijan

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Abstract: Dry reference collections of plants and fungi serve as essential repositories of the global flora and funga diversity, preserving specimens that provide critical data for scientific research, environmental monitoring, and conservation. By maintaining accurate records of species distribution and diversity, herbaria and fungaria contribute to understanding ecosystem dynamics and to guiding sustainable management of natural resources worldwide. This study presents a comprehensive assessment of *Cercospora* species in Azerbaijan based on dry specimens collected over various periods and preserved in the fungarium (BAK), together with a review of published records from the country. Studied specimens were examined for conidiophores and conidia morphological characters, allowing accurate species identification within the genus and their names alignment with current taxonomic revisions and novelties. As a result of this work, 18 species of *Cercospora* are currently listed for Azerbaijan in the fungarium. These species are associated with 20 host plant species representing 17 genera, 13 families, and 12 orders. Most of the fungi invaded predominantly different weed plants. The highest number of fungal species occurred on hosts from the families Fabaceae (*C. rautensis*, *C. traversoana*, *C. zebrina*, *C. zonata*) and Malvaceae (*C. althaeina*, *C. malvarum*, *C. malvicola*), whereas *Cercospora* invading other plant families was represented by only one fungal species in each. Analysis of *Cercospora* species distribution revealed that most fungal specimens were collected in the Greater Caucasus and the Nakhchivan mountain regions, with five species found in each region.
Keywords: *cercosporoid fungi, conidia, conidiophore, diagnostic characters, distribution, herbarium, host plant, morphology, pathogen, dry specimen*

INTRODUCTION

Fungi of the genus *Cercospora* Fresen. ex Fuckel are a group of hyphomycetes that cause leaf spots and have a worldwide distribution. These fungi produce mainly internal primary and rarely external secondary mycelium. The primary mycelium is usually septate, branched, thin-walled, hyaline or pale olivaceous to olivaceous-brown. Meanwhile, the internal mycelium often forms swollen hyphal cells that gather in dense clusters that develop into stroma [Shin et al., 2001; Braun et al., 2013]. The anamorphic genus *Cercospora* is classified in the ascomycetous family Mycosphaerellaceae (Mycosphaerellales) and includes plant-pathogens and some endophytic species [Braun, 1999; Stewart et al., 1999; Crous et al., 2000]. These fungi develop fructifications with conidiophores and conidia on the leaves, which are visible on leaf spots and could be located epiphyllous, hypophyllous or amphigenous.

The first published monograph listed 1419 species within the genus [Chupp, 1954], then number of identified *Cercospora* species has expanded to 3000 species [Pollack, 1987]. The concepts of the *Cercospora* genus have been thoroughly reviewed by F.C. Deighton [1967], U. Braun [1995]. Based on these earlier works, P. Crouse and U. Braun [2003] conducted a more comprehensive reassessment of the genus, in which they recognized 659 validly published names attributed to *Cercospora*, regarding such morphological characters as the structure of the conidiogenous loci, the hilus, and the presence or absence of pigmentation in the conidiophores and conidia. It should also be considered that the type species of the genus is *Cercospora apii* Fresen., which according recent studies represents a morphologically indistinguishable species complex [Crous, Braun, 2003] with more than 281 names referred to *C. apii s. lat*. [Groenewald et al., 2013; Vaghefı et al., 2018]. Recently M. Groenewald [Groenewald et al., 2013] and P. Crous [Crous et al., 2015] gave particular emphasis on *Cercospora* and *Pseudocercospora* Speg., respectively. Thus, the definition of *Cercospora* genus was gradually expanded since the introduction in 1863.

Received: 21.05.2025; Received in revised form: 23.09.2025; Accepted: 22.12.2025
Citation: Apbayeva Kh.R., Aghayeva D.N., Andrianova T.V. (2025) Revision of the genus *Cercospora* Fresen. ex Fuckel in the fungarium (BAK) of Azerbaijan. *Plant & Fungal Research*, 8(2): 28-38.

Species of this genus have traditionally been named after the host plants from which they were isolated or identified [Chupp, 1954; Ellis, 1971; Braun, 2003]. However host specificity in *Cercospora* is poorly understood up to now, and some species are known to cause leaf spot symptoms when infecting other hosts [Weiland, Koch, 2004; Groenewald et al., 2006]. In general, most of the known *Cercospora* species are indeed serious plant pathogens, usually provoking the development of leaf spots, which are common symptoms of numerous plant diseases. Some *Cercospora* species are agricultural, horticultural and forest pathogens. Of these species, *Cercospora apii* which is responsible for celery early blight [Yang et al., 2023], *Cercospora beticola* Sacc. which is the causal agent of shugar beet disease [Groenewald et al., 2007; Bakhshi et al., 2011; Rangel et al., 2020] and *Cercospora violae* Sacc. which affects garden violet [Dal Bello, Wolcan, 2002; Trkulja et al., 2015] are most aggressive pathogens.

The evolutionary relationship between different *Cercospora* species have recently been investigated using protein-coding genes [Groenewald et al., 2013], and several next studies have been focused on the analysis of multiple loci to help in species delimitation [Bakhshi et al., 2015, 2018; Huang et al., 2015; Guatimosim et al., 2016]. The studies have indicated that the expansion of host range and adaptive radiation in *Cercospora* species may be influenced by their ability to produce cercosporin, a phytotoxic metabolite of polyketide origin found in those fungi [Fajola, 1978; Daub, Ehrenshaft, 2000; Goodwin et al., 2001]. However, since not all species produce cercosporin, it cannot be considered a universal factor of pathogenicity or a compound that universally enhances virulence [Goodwin et al., 2001].

Identification of *Cercospora* fungal specimens in Azerbaijan has traditionally been based on the study of external mycelium growth, general morphological characters of fructifications and host specificity. Mycobiota of Azerbaijan [Akhundov et al., 2008] reports 97 species for the genus *Cercospora*. A total of 78 herbarium specimens, representing 42 species named under genus *Cercospora*, are preserved at the fungarium of the Institute of Botany (BAK). The aim of this study was to review the available dry fungal specimens and literature data on the genus *Cercospora*, the host range of these species and their distribution in the country.

MATERIAL AND METHODS

Fungal specimens defined as *Cercospora* in the fungarium of the Institute of Botany (BAK) were examined using traditional morphological methods for typical sporulation and details of structures (Fig. 1). The specimens were mounted in distilled water and examined under the light microscope (Nikon Eclipse E100, Japan; Vert. A1, Carl Zeiss, Axio Imager, Göttingen, Germany). Colourless structures were visualised by lactophenol as fixative only, without any additional stain. Measurements of each main diagnostic characters, such as the length of conidiophores and conidia, were done 15–20 times at magnification × 40, and the shape of morphological structures was also taken into account.

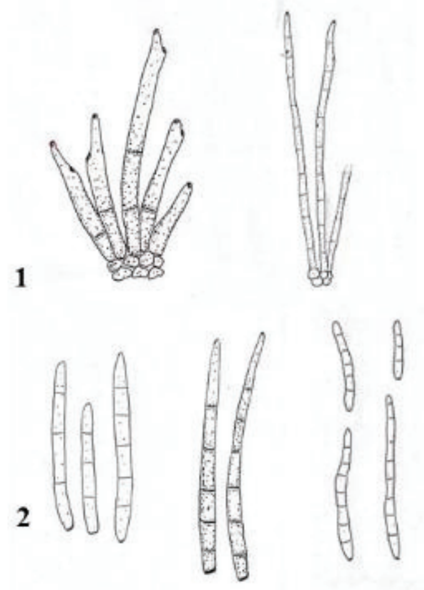

Figure 1. Main diagnostic structures of the genus *Cercospora* sporulation: 1. fasciculate conidiophores, 2. conidia [by Braun, 1995; Braun, Melnik, 1997].

The list of *Cercospora* species published in the Mycobiota of Azerbaijan [Akhundov et al., 2008] was also considered. Available monographic works and publications were used for accurate species identification, which was carried out on the basis of the provided morphological descriptions [Chupp, 1954; Braun, Melnik, 1997; Braun, 2000, 2001, 2003; Braun, Crous, 2007; Groenewald et al., 2013]. The taxonomic position of studied *Cercospora* species have been updated according to the information in the world databases of Mycobank and Index Fungorum. Nomenclature and taxonomic position of host plants and plant families are based on the Angiosperm Phylogeny IV system [APG IV, 2016].

RESULTS AND DISCUSSION

The study revealed that of the 42 species of cercosporoid fungi recorded in Azerbaijan, only 18 species are currently classified in the genus *Cercospora*. The species names have been updated to reflect recent advances in the taxonomy of the genus. Provided list of *Cercospora* species contains a brief information on each species, including current name of the fungus and its synonyms mentioned for Azerbaijan, dry collection numbers of specimens in BAK, the place of collection, date, and host plant.

Cercospora agnostoica Speg., Revista del Museo de La Plata 15(2): 45, 1908.

On *Symphytum asperum* Lepech. (Boraginaceae, Boraginales), Shahbuz district, Nakhcivan AR, 25.06.1967, BAK 644.

The specimen is in a deteriorated state and does not appear to have diagnostic features of the genus *Cercospora*. According to U. Braun [2000], this species is a true *Cercospora s.str.* based on fragments of the holotype of the species, and conspecific with *C. apii s.lat*. Species of true *Cercospora* can be distinguished from the *C. apii s. lat.* complex by its short, aseptate or rarely septate, pale conidiophores and acicular to obclavate conidia [Braun et al., 2015]. Host specificity and the processes of speciatialization in *Cercospora* remain largely unclear. However, certain species have been observed to produce leaf spot symptoms on range of hosts [Chupp, 1954]. Species of the *C. apii s. lat.* complex have hosts from different families, included in Boraginaceae, such as *C. cynoglossi* J.M. Hook on *Cynoglossum officinale* Willk., *C. echii* Winter on *Echium vulgare* L., *C. echiorum* Maire ex Sacc. on *Echium creticum* L. and *C. lithospermi* Chupp & H.C. Greene on *Lithospermum carolinense* var. *crocerum* (Fernald) Cronquist. Due to its damaged condition, the specimen was left under its previous name.

Cercospora althaeina Sacc., Michelia 1(no. 2): 269, 1878. Syn.: *Cercospora kellermanii* Bubák, *Cercospora praecincta* (Davis) Chupp, *Cercosporina ramularia* (Siemaszko) Sacc.

On *Malva setigera* K.F. Schimp. & Spenn. (Malvaceae, Malvales), Guba district, 21.09.1977, BAK 646.

The specimen is in a damaged condition and does not appear to have diagnostic morphological characters of the genus *Cercospora*.

Cercospora apii Fresen., Beiträge zur Mykologie 3: 91, 1863. Bas.: *Cercospora apii* Fresen. Syn.: *Cercosporina apii* (Fresen.) Miura., *Cercospora levistici* Kwashn.

On *Apium graveolens* L. (Apiaceae, Apiales); Guba district, 26.06.1976, BAK 653, Fig. 2:1-2.

In the examined specimen the spots caused by the fungus are yellowish-brown with dark brown margins. Conidiophore aggregations are hypophyllous, mostly very small, brown, punctiform, and fasciculate. Conidiophores light brown, straight or slightly curved, smooth, geniculate, broad, with prominent scars, 35–76 × 4–6 µm. Conidia hyaline, obclavate or acicular, gradually narrowing toward the apex, base broad and truncate, multiseptate, 43–70 × 2–5 µm.

Cercospora beticola Sacc., Nuovo Giornale Botanico Italiano, 8(2): 189, 1876. Syn.: *Cercosporina beticola* (Sacc.) Nakata, T. Nakajima & K. Katimoto, *Cercospora longissima* Cooke & Ellis

On *Beta vulgaris* L. (Amaranthaceae, Caryophyllales), Fuzuli district, 10.06.1941, BAK 657. Fig. 2:3-5.

In the examined specimen, the spots caused by the fungus were yellowish, mostly circular, sometimes irregular in shape, occasionally merging to form larger lesions, bordered with ochraceous margins. Conidiophores fasciculate, fascicles very dense, light brown, straight or sometimes curved, with distinct conidial scars, 29–77 × 4–5 µm. Conidia hyaline, filiform, slightly curved at the apex, with 7 faintly visible septa, 67–108 × 3 µm.

Cercospora bizzozeriana Sacc. & Berl., Malpighia 2(5–6): 248, 1888. Bas.: *Cercospora bizzozeriana* Sacc. & Berl. Syn.: *Cercospora drabae* Bubák & Kabát

On *Lepidium campestre* (L.) W.T. Aiton (Brassicaceae, Brassicales), Guba district, 02.09.1977, BAK 673. Fig. 2:6-8.

In the examined specimen the spots caused by the fungus were yellowish-brown, with dark margins, irregular in shape. Conidiophores short, light brown (darker toward the base), conidiogenous loci darkened, 48–67 × 4–5 µm. Conidia solitary, hyaline, straight or slightly curved, cylindrical, obconically truncate or truncate, distinctly thickened at the base, obtuse at the apex, 67–104 × 4–6 µm, 1–11-septate.

Cercospora elaterii Pass., Hedwigia 16(6): 123, 1877.

On *Ecballium elaterium* (L.) A. Rich. (Cucurbitaceae, Cucurbitales), Khachmaz district, 05.06.1976, BAK 712. Fig. 2: 9-11.

In the examined specimen spots caused by the fungus were dark brown, mostly circular, sometimes irregular in shape. Conidiophore groups were epiphyllous and dense, with dark brown stromata. Conidiophores reddish-

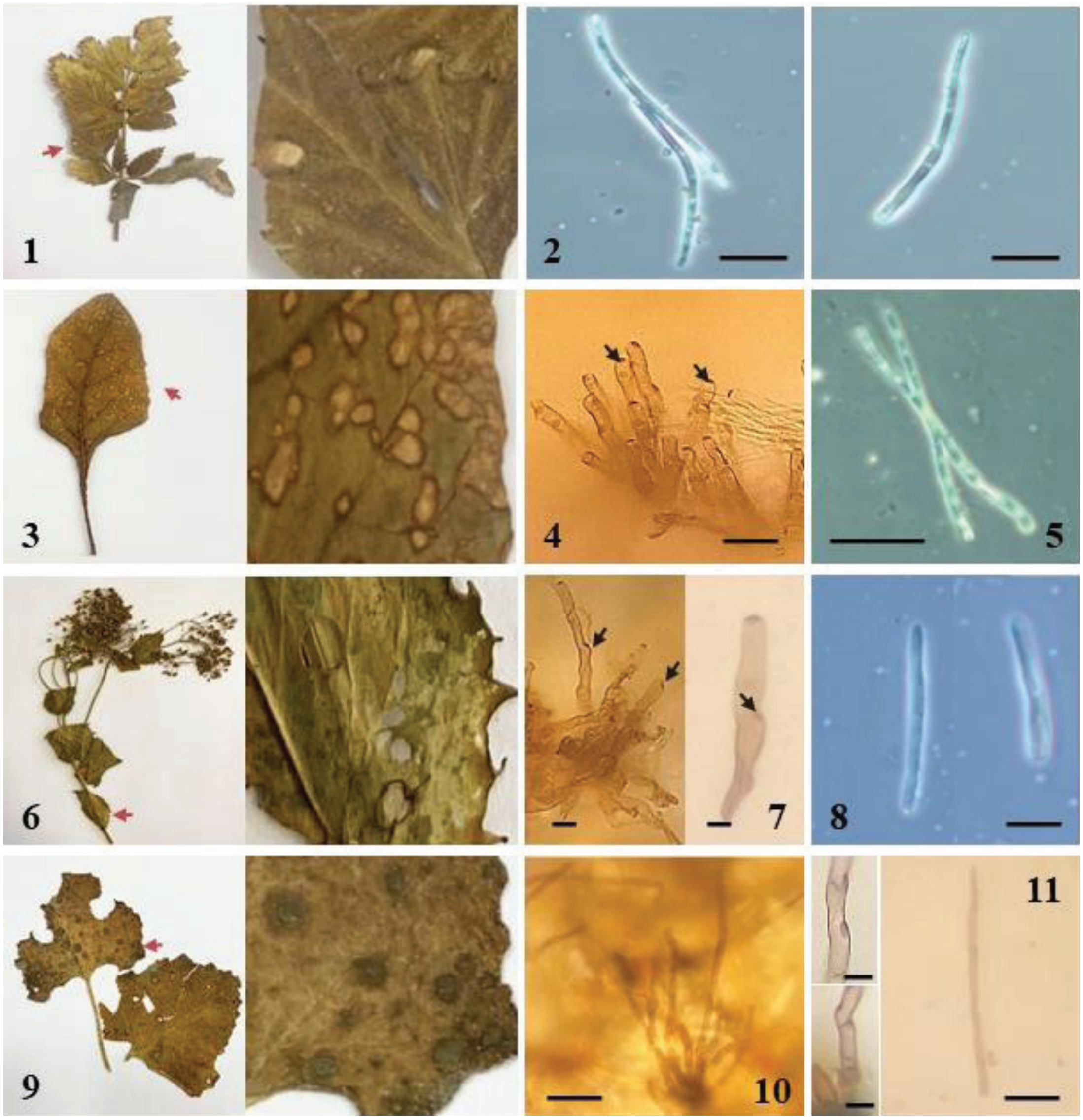

Figure 2. Species of the genus *Cercospora*: symptoms on plants, conidiophores and conidia respectively. Red arrows indicate spots, while black arrows indicate conidial scars. 1-2. *C. apii*. 3-5. *C. beticola*. 6-8. *C. bizzozeriana*. 9-11. *C. elaterii*. Bar: 20 µm.

brown, straight or sometimes curved, septate, 58–162 × 3–5 µm. Conidia light brown, thin-walled, straight or occasionally curved, cylindrical, with indistinct septa, 55–146 × 3–5 µm.

Cercospora elongata Peck, Annual Report on the New York State Museum of Natural History 33: 29, 1880. Syn.: *Cercosporina scabiosicola* Rangel, *Cercospora knautiae* Siemaszko, *Cercospora dipsaci* Hollós

On *Lomelosia rotata* (M. Bieb.) Greuter & Burdet (Caprifoliaceae, Dipsacales), Tovuz district, 05.08.1981, BAK 713.

The specimen examined is in damaged condition. The spots caused by the fungus were circular or irregular in shape, initially greenished, later turning brown, with dark margins. Conidiophores were broken or not developed well, mostly very short or occasionally longer, brown, 12–17 × 5 µm. Conidia were not observed.

Cercospora malvarum Sacc., Michelia 2(7): 365, 1881.

On *Alcea tabrisiana* (Boiss. & Buhse) Iljin (Malvaceae, Malvales), Ordubad district, Nakhchivan AR, 15.06.1961, BAK 722, Fig. 2: 12-14.

In the examined specimen angular spots caused by the fungus were observed, that vary in color from light to

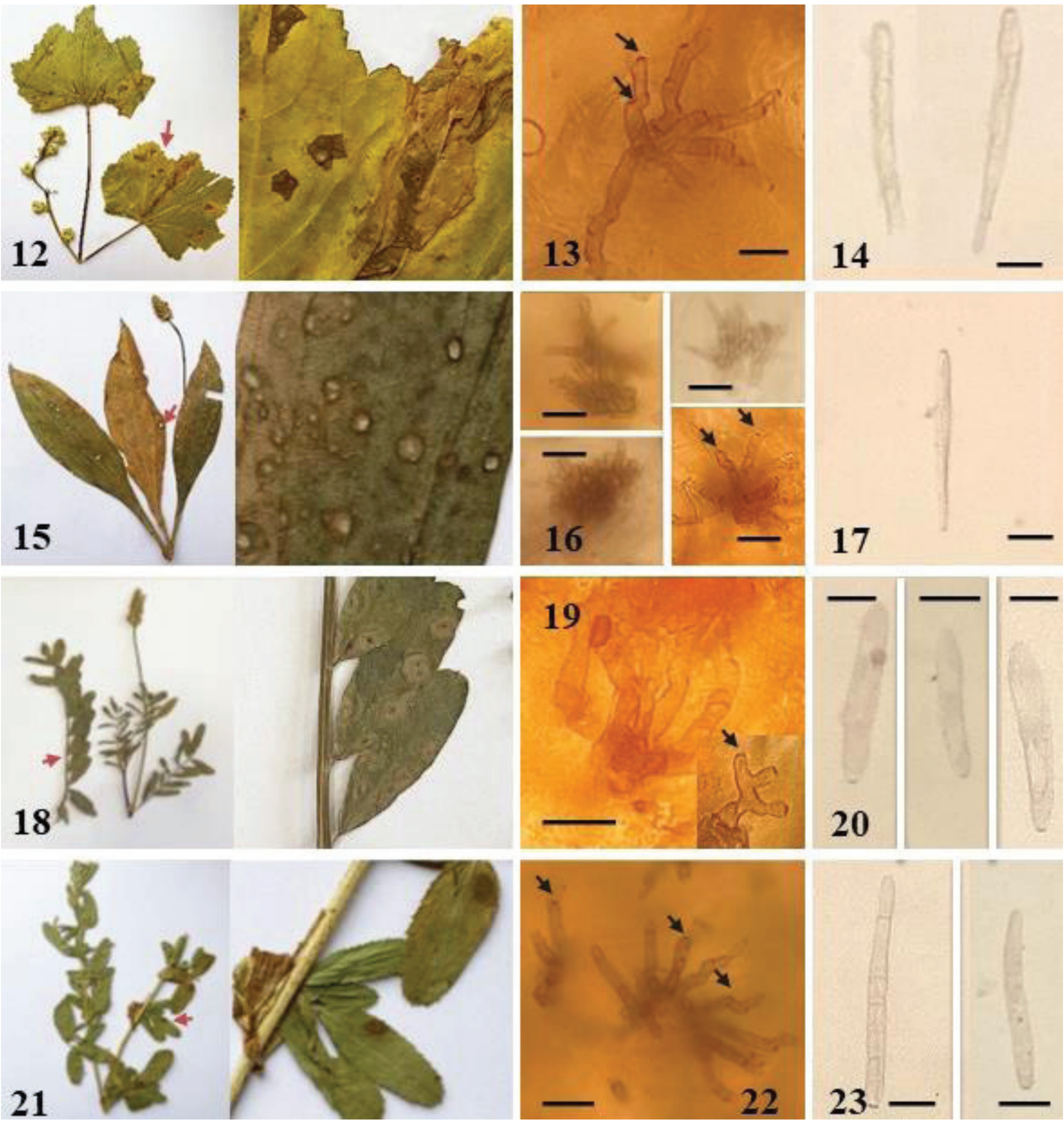

Figure 2 (continued). Species of the genus *Cercospora*: symptoms on plants, conidiophores and conidia respectively. Red arrows indicate spots, while black arrows indicate conidial scars. 12-14. *C. malvarum*. 15-17. *C. plantaginis*. 18-20. *C. rautensis*. 21-23. *C. traversoana*. Bar: 20 µm.

dark brown, with dark margins. Conidiophores nodulose, light brown, with clearly visible conidial scars, 24–38 × 4–5 µm. Conidia straight to slightly curved, tapered at the apex, hyaline, 0–4-septate, 29–65 × 3–5 µm.

Although this specimen is recorded in the BAK fungarium as *Cercospora malvarum*, based on the size of the conidiophores and conidia as well as other morphological characters, it is more consistent with *Cercospora malvicola*.

Cercospora malvicola Ellis & G. Martin, The American Naturalist 16: 810, 1882. Bas.: *Cercospora malvicola* Ellis & G. Martin. Syn.: *Cercospora polymorpha* Bubák

On *Malva* sp. (Malvaceae, Malvales), Masalli district, 21.12.1969, BAK 745.

The specimen is in a damaged condition and does not appear to have diagnostic morphological characters of the genus *Cercospora*.

Cercospora moricola Cooke, Grevillea 12(61): 30, 1883.

On *Morus alba* L. (Moraceae, Rosales), Lankaran district, 12.07.1967, BAK 736, Zagatala district, 12.07.1990, BAK 737.

In the examined specimen leaf spots caused by the fungus vary from circular to irregular, 1–8 mm in diam., gray to black, with margins ranging from dark purple to black. Groups of conidiophores are amphigenous, fascicles are very dense. Conidiophores are light or pale brown, nearly hyalinous at the apex, the longest ones wavy or curved, unbranched, rarely geniculate, septa are not visible, 65–98 × 2–3.5 µm. Conidiophores in this specimen are significantly larger than it was indicated by C. Chupp [1954], which is 5–30 × 2–3.5 µm. Conidia were not observed.

Cercospora plantaginis Sacc., Michelia 1(2): 267, 1878. Syn.: *Cercospora plantaginella* Tehon

On *Plantago lanceolata* L. (Plantaginaceae, Lamiales), Ordubad district, Nakhchivan AR, 15.06.1961, BAK 743, Bilasuvar district, 04.06.1978, **BAK 744**, Fig. 2: 15-17.

In the examined specimen leaf spots caused by the fungus are circular, sometimes angular, first whitish gray, then turning light brown towards the margins. Stromata are present; conidiophores short, straight or slightly curved, with thickened base, rounded apex, 1-septate, sometimes swollen above the septum; conidial scars are distinct, 17–72 × 3.6–4.8 µm. Conidia straight, slightly curved at the apex, pointed, indistinctly multi-septate, hyaline, 60–74 × 2.5 µm.

Cercospora rautensis C. Massal., Madonna Verona, Bollettino del Museo Civico di Verona 3: 19, 1909. Syn.: *Cercospora coronillae-scorpioidis* Ferraris.

On *Coronilla varia* L. (Fabaceae, Fabales), Guba district 20.07.1977, BAK 753, Lerik district, 24.06.1973, **BAK 752**, Fig. 2: 18-20.

In the examined specimen, the spots caused by the fungus are amphigenous, mainly hypophyllous, grayish, not delimited by veins. Conidiophores fasciculate, fascicles with 4–6 conidiophores, pale brown, paler and tapering toward the apex, straight, sometimes curved, geniculate or wavy, unbranched or occasionally branched, with well-developed conidial scars, 24–34 × 3–4 µm. Conidia straight, sometimes curved, cylindrical to obclavate, 0(1)–3-septate, hyaline, 22–48 × 3–5 µm.

Cercospora traversoana Sacc., Annales Mycologici 2 (1): 18, 1904. Syn.: *Cercospora traversiana* Sacc., *Cercospora trigonellae* Maubl.

On *Ononis arvensis* L. (Fabaceae, Fabales), Ordubad district, 26.06.1964, BAK 760, Fig. 2: 21-23.

In the examined specimen spots caused by the fungus are amphigenous, circular or subcircular, up to 1 cm wide, with reddish-yellow or brown margins. Conidiophores flexible, brown, becoming paler toward the apex, 24–50 × 4–5 µm, with developed conidial scars. Conidia straight, olivaceous, filiform to acicular, sometimes cylindrical, tapered toward the apex, 29–89 × 3–5 µm, 3–7-septate.

Cercospora verbascicola Ellis & Everh., Journal of Mycology 4 (1): 3, 1888.

On *Verbascum phlomoides* L. (Scrophulariaceae, Lamiales), Guba district, 18.07.1977, BAK 761, 10.08.1977 BAK762.

In the examined specimen leaf spots caused by the fungus were angular, circular to subcircular, from brown or pale black to dull gray, sometimes with a purple margin. The groups of conidiophores are predominantly epiphyllous, rarely hypophyllous, darkening the grayish leaf surface. Fascicles usually consist of 2-4 distinct conidiophores. Conidiophores dark brown, becoming paler and narrower toward the apex, unbranched, straight to slightly curved, rarely 1–3 geniculate, with a narrow, rounded apex, 10-31× 3-4 µm. Conidia hyaline, filiform to acicular, straight to curved, 50–79 × 4-6 µm, indistinctly multiseptate, obtuse at the base and tapered at the apex. Observed size of conidiophores and conidia differ from those reported in publications. According to C. Chupp [Chupp 1954] conidiophores could be much longer, 60–1000 × 4–6 µm, as well as conidia, 60–400 × 3–4 µm.

Cercospora violae Sacc., Mycoth. Ven. Cent. III: no. 279, 1875. Syn.: *Cercospora violae-tricoloris* Briosi & Cavara, *Cercospora violae-kiusianae* Sawada

On *Viola* sp. (Violaceae, Malpigiales), Ordubad district, 15.06.1961, BAK763, Tovuz district, 28.07.1981, BAK 764.

In the examined specimens the spots caused by the fungus are amphigenous, circular, gray in the center, with bright yellow or whitish peripheral part and reddish margin. Conidiophores dense, long or occasionally short, straight or sometimes curved, from hyaline to brownish in color, septate, 50–77 × 3.6–4.8 µm. Conidia straight or slightly curved, filiform, hyaline, multiseptated, 86–240 × 2.8–4.8 µm.

Cercospora zebrina Pass., Fungi Europaei exsiccati Cent. 23: no. 2277, 1877. Syn.: *Cercosporina zebrina* (Pass.) Matsuura, *Cercospora helvola* Sacc., *Cercospora stolziana* Magnus, *Cercospora helvola* var. *zebrina* Ferraris

On *Trifolium spumosum* L., *T. campestre* Schreb., *T. ambiguum* M. Bieb. (Fabaceae, Fabales), Lankaran district 01.06.1974, BAK766, Yardimli district, 07.06.1974, BAK767, Lachin district, 26.06.1975, BAK 769.

In the specimens examined the spots caused by the fungus were amphigenous, irregular in shape, brownish black in color. Conidiophores straight, reddish-brown, darker at the base and paler at the apex, 26–48 × 4–5 µm. Conidia were not observed.

Cercospora zonata G. Winter, Boletim da Sociedade Broteriana 1, 2: 49, 1884. Syn.: *Cercospora viciae* Ellis & Holw., *Cercospora fabae* Fautrey

On *Vicia narbonensis* L. (Fabaceae, Fabales), Julfa district, 01.06.1963, BAK 770.

In the examined specimen leaf spots caused by the fungus range from subcircular to angular, often with concentric zones, 2-12 mm in diam., brown to grayish with dark brown margins. Conidiophores fasciculate, in small groups, straight to slightly curved, brown, septate, 36–60 × 4–5 µm. Conidia slightly curved, cylindrical, with olivaceous tint, 3–5-septate, 36–62 × 3–4 µm.

Cercospora zygophylli Szembel, Mater. Mikol. Fitopatol. Rossii: 111, 1915.

On *Zygophyllum fabago* L. (Zygophyllaceae, Zygophyllales), Ganja city, 15.08.1980, BAK 774.

In the examined specimen the leaf spots caused by the fungus were amphigenous, circular, bright yellow with a dark margin. Conidiophores were straight, cylindrical, hyaline, septate, 12–19 × 4–5 µm. Conidia were not observed.

Host plant diversity. The taxonomic structure of host plant species that were invaded by studied *Cercospora* fungi, as well as the frequency of distribution of *Cercospora* fungal infections across plant families, were analyzed (Tab. 1, Fig. 3). The fungi of this genus have been recorded on 20 species of angiosperms from 17 genera, 13 families and 12 orders. The registered *Cercospora* species are host specific. The highest number of fungi were found on the host plans of the families Fabaceae (*C. rautensis*, *C. traversoana*, *C. zebrina*, *C. zonata*), followed by Malvaceae (*C. althaeina*, *C. malvarum*, *C. malvicola*). All other plant families were represented by only one species.

Observation of host plant life forms revealed that all recorded *Cercospora* species were collected on herbaceous plants, with the exception of *Cercospora moricola*, that was found on the tree of *Morus alba*.

Distribution patterns of species. The analysis of the species distribution was carried out based on the botanical and geographical atlas of Azerbaijan [National Atlas, 2014]. The frequency of occurrence of *Cercospora* specimen collections in regions was analysed, and encountered species distribution was mapped (Fig. 3). The Greater Caucasus (the Guba mountain range) is represented by the species of *Cercospora althaeinae*, *C. apii*, *C. bizzozeriana*, *C. rautensis* and *C. verbascicola*, the Nakhchivan mountainous region is characterized by *Cercospora agnostoica*, *C. malvarum*, *C. plantaginis*, *C. traversoana* and *C. violae*, the Lankaran-Mugan botanic-geographical region is represented by *C. moricola*, *C. plantaginis* and *C. malvicola* and the Kura plain is characterized by *C. elongata*, *C. violae* and *C. zygophylli*.

CONCLUSIONS

Herbaria and fungaria are vital repositories of bio-diversity, data needed for research and conservation worldwide [LaGreca et al., 2025]. They provide essential support for tackling important scientific

Table 1. Taxonomic structure of host plants invaded by the fungi of the genus *Cercospora* in Azerbaijan.

Orders	Number of families	Families in %	Number of genera	Genera in %	Number of species	Species in %
Zygophyllales	1	7.69	1	5.88	1	5
Fabales	1	7.69	4	23.53	6	30
Rosales	1	7.69	1	5.88	1	5
Cucurbitales	1	7.69	1	5.88	1	5
Malpighiales	1	7.69	1	5.88	1	5
Malvales	1	7.69	2	11.76	3	15
Brassicales	1	7.69	1	5.88	1	5
Caryophyllales	1	7.69	1	5.88	1	5
Boraginales	1	7.69	1	5.88	1	5
Lamiales	2	15.38	2	11.76	2	10
Dipsacales	1	7.69	1	5.88	1	5
Apiales	1	7.69	1	5.88	1	5
12	13	100.0	17	100.0	20	100.0

Figure 3. Distribution of studied *Cercospora* species across Azerbaijan.

challenges. These collections, if properly analyzed, can be an invaluable tool for documenting changes in biodiversity over the past century [Rostański et al., 2024; Hart et al., 2025]. In many regions, especially in resource-poor countries, such collections remain largely "silent" or under-utilized. It is estimated that only 10% of biological collections have been digitized and made available in digital format [Ball-Damerow et al., 2019]. Historical data on previous events are needed as to document population and species decline or wide distribution. Numerous fungaria contain such information on fungi for the most regions of the world.

In this study, samples of 18 *Cercospora* true species associated with various host plants and stored in BAK were examined. However, a significant number of this genus species known for Azerbaijan have been reported mainly in the two comprehensive compendiums published over the past 25 years. About 42 species names are reported by U. Braun and V. Melnik [1997] and 97 species names were included into the fifth volume of "Mycoflora of Azerbaijan" [Akhundov et al., 2008]. Understanding of some species taxonomy changed over the last years and the species, such as *C. elongata*, *C. curvata*, *C. pantoleuca*, *C. potentillae*, *C. punctiformis*, *C. fusimaculans* and *C. vulpinae* are transferred to other close genera. At the same time, some specimens of the true *Cercospora* species, including holotypes of *C. adonidis*, *C. bryoniae* and *C. potentillae* described from Azerbaijan have been redeposited to LE and they are unavailable for the further study [Braun, Melnik, 1997].

It is important to note that before Azerbaijan gained independence in 1992, the majority of dry collections, including holotypes, were stored in the central herbaria and fungaria such as LE and MW, primarily due to the prevailing political and economic circumstances of that period. The list of host species for *Cercospora* provided in the volume of T.M. Akhundov [Akhundov et al., 2008] includes plants that are widespread throughout the country and are typical hosts for this genus of fungi. That suggests that a greater diversity of *Cercospora* species may be present in the region. Continued efforts to locate and collect in nature the missing fungarium specimens are feasible and warranted.

REFERENCE

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Azərbaycan funqariumunda *Cercospora* Fresen. ex Fuckel cinsinin (BAK) təftişi

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Elmi tədqiqatlar, eləcə də ətraf mühitin monitorinqi və konservasiyası üçün kritik məlumatları təmin edən nümunələri mühafizə edən bitki və göbələklərin quru istinad kolleksiyaları qlobal floranın mühüm deposu kimi xidmət edir. Növlərin yayılması və müxtəlifliyi haqqında dəqiq qeydlərin aparılması ilə herbari və funqarilər ekosistem dinamikasının dərk edilməsinə və təbii resursların davamlı idarə olunmasına töhfə verir. Bu tədqiqat müxtəlif dövrlərdə toplanılan və funqariumda (BAK) saxlanılan quru nümunələr əsasında Azərbaycanda *Cercospora* növlərinin hərtərəfli qiymətləndirilməsini və ölkədə çap olunmuş materialların xülasəsini təqdim edir. Araşdırılan nümunələrdə cins daxilində növlərin dəqiq təyininə və onların adlarının cari taksonomik düzəliş və yeniliklərlə uyğunlaşdırılmasına imkan verən konidioforlar və konidilərin morfoloji xüsusiyyətləri tədqiq olunmuşdur. Hal-hazırda, Azərbaycan funqariumunda 18 *Cercospora* növü qeyd olunmuşdur. Bu növlər 20 sahib bitki ilə əlaqəlidir ki, onlar 17 cins, 13 fəsilə və 12 sıranı təmsil edir. Əksər göbələklər əsasən müxtəlif alaq bitkilərini yoluxdurur. Ən çox göbələk növü Fabaceae (*C. rautensis*, *C. traversoana*, *C. zebrina*, *C. zonata*) və Malvaceae (*C. althaeina*, *C. malvarum*, *C. malvicola*) fəsilələrinə aid sahib bitkilərdə müşahidə olunmuş, digər bitki fəsilələrinin hər biri yalnız bir *Cercospora* növü ilə təmsil olunmuşdur. *Cercospora* növlərinin yayılmasının analizi göstərmişdir ki, əksər nümunələr hər bölgədə beş növ olmaqla Böyük Qafqaz və Naxçıvan dağlıq bölgələrindən toplanmışdır.

Açar sözlər: *sekosporoid göbələklər, konidilər, konidiofor, diaqnostik xarakterlər, yayılma, herbarium, sahib bitki, morfologiya, patogen, quru nümunə*

Ревизия рода *Cercospora* Fresen. ex Fuckel в фунгарии (BAK) Азербайджана

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Сохранение образцов сухих коллекций служит важнейшим депозитарием разнообразия растений и грибов, и содержит важную информацию для научных исследований, мониторинга окружающей среды и охраны природы. Ведение в гербариях и фунгариях точных записей с данными о распространении и разнообразии видов способствует пониманию динамики экосистем и содействуют устойчивому управлению природными ресурсами во всём мире. В этом исследовании представлен всесторонний анализ видов *Cercospora* в Азербайджане на основе сухих коллекций, собранных в разные периоды и хранящихся в фунгариуме (BAK), а также обзор опубликованных данных по стране. Для изученных образцов были исследованы морфологические признаки конидиеносцев и конидий, что позволило провести точную идентифицикацию видов, принадлежащих роду, и привести в соответствие с современными таксономическими изменениями и нововведениями их названия. В результате работы в настоящее время зарегистрировано 18 видов *Cercospora* в фунгариуме Азербайджана. Эти грибы развиваются на 20 видах растений-хозяев, представленных 17 родами из 13 семейств 12 порядков. Большинство грибов преимущественно поражало различные сорные растения. Наибольшее количество видов грибов обнаружено на растениях-хозяевах из семейств Fabaceae (*C. rautensis*, *C. traversoana*, *C. zebrina*, *C. zonata*) и Malvaceae (*C. althaeina*, *C. malvarum*, *C. malvicola*), тогда как в других семействах растений род *Cercospora* был представлен только одним видом в каждом из семейств. Анализ распространения видов *Cercospora* показал, что большинство образцов грибов собрано в горных регионах Большого Кавказа и Нахчывана, в каждом из которых обнаружено по пять видов.

Ключевые слова: *церкоспороидные грибы, конидия, конидиеносец, диагностические признаки, распространение, гербарий, растения-хозяева, морфология, патоген, сухой образец*