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Microfungi species observed on various weed species in the Yüksekova Basin, Türkiye

Yüksekova Havzasında yabancı otlar üzerinde tespit edilen mikrofungus türleri

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ABSTRACT

Studies on biological control for the sustainable management of weeds that exert serious ecological, economic, and human health problems are attracting increasing attention. Detection of potential biological control agents (pests, pathogens, etc.) on target weed species is the first step in the biological control program. This study aimed to determine the microfungi species found on noxious weed species in the Yüksekova basin situated in Hakkari province, Türkiye. Continued traditional agricultural practices, minimum or no use of pesticides and fertilizers, and better protection of natural flora/fauna compared to other parts of Türkiye were reasons for the selection of the basin in the current study. Field surveys were carried out in different periods during 2020 and 2021. A total of 101 microfungi species were recorded on 79 weed species belonging to 29 families in the basin. The most common fungi species in the basin were in genera Puccinia (29 species), *Alternaria* (18 species), *Uromyces* (14 species), and *Curvularia* (4 species). Weed hosts of the above-mentioned fungi species mostly belonged to Asteraceae (20 species), Fabaceae (7 species), Poaceae (7 species), and Lamiaceae (6 species) families. While 84 microfungi species were recorded on a single host, and the remaining 17 were found on more than one weed species. It has been observed that *Puccinia cyani* (Schleich.) Pass., *Puccinia chondrillina* Bub & Syd., and *Uromyces polygoni-avicolariae* (Pers.) P. Karsten significantly inhibited the growth and development of their host weed species (*Centaurea* spp., *Chondrilla juncea* L., and *Polygonum aviculare* L.) and were able to suppress the populations of the weeds in the fields. The results revealed that it would be beneficial to review the recorded pathogens in terms of biological activity and to carry out detailed field studies in the region.

INTRODUCTION

Weeds and invasive alien plant species can pose serious ecological, economic, and human health risks in agricultural ecosystems and natural areas. Therefore, weed management is indispensable for the sustainability of these areas (Önen 2015). Weeds cause significant yield and quality losses in crops, retard the development of crop plants with

allelopathic effects, serve as hosts for diseases and pests, make soil cultivation and harvesting difficult, and waste resources and time in agroecosystems (Önen 2006, Önen 2013, Önen 2021a, Özaslan et al. 2015, Özer et al. 2001, Zimdahl 2018). Therefore, weeds are one of the most important factors limiting agricultural production. Besides, weeds endanger human and animal health with their poisonous effects (Önen 2021b, Zimdahl 2018). Hence, it is anticipated that the management of weeds will become increasingly important in the future (Önen 2010a, Önen and Özcan 2010, Özaslan et al. 2016).

Yield losses caused by weed infestation can reach up to 10-90% (Önen 1995, Pätzold et al. 2020), which makes weed management mandatory (Önen and Özer 2001, Önen 2020). Herbicides have become an important weed management option, especially in conventional farming systems (Önen and Kara 2008). Herbicides are easier to use, give results in a short time, and are cheaper than other weed control methods, all of which increased their usage (Önen 2021c). The frequent use of herbicides has been posing significant risks to human health and the environment (Önen 2010b). Besides, an increase in herbicide resistance weed species has also been reported from all over the world. Recent years have seen a rise in environmental consciousness due to growing concerns about pesticide residues and a decline in ecosystem services (Önen 2014). Emerging public pressure has increased the tendency towards environmentally friendly alternative approaches such as biological control (Atay et al. 2015, Önen 2014).

Biological control is a weed management strategy that can be defined as preventing the growth/development of weeds and keeping their population below the economic threshold level by using different agents such as insects, fungi, bacteria, and viruses (Atay et al. 2015, Önen and Kara 2008). Although different organisms are used in biological control, fungi have a privileged place due to their high number of species, ability to reproduce easily in artificial environments, specialization to a single host, and suitability for commercial production (Eken and Demirci 1997, Uygur and Uygur 2010). It has been revealed that several microfungi can be used as biocontrol agents against different weed species (Amsellem et al. 2002, Atay et al. 2015, Bailey 2014, Berner et al. 2015, Eken and Demirci 2002, Harding and Raizada 2015, Kiss 2003, Özaslan 2011, Rector et al. 2006, Tepe and Özrenk 1999). Bio-herbicides containing different fungal pathogens are commercially available worldwide for weed management, especially in America, Canada, China, and South Africa (Triolet et al. 2020). For instance, the biocontrol product Lubao No: 1S22Ò has been used in the management of dodder (*Cuscuta* spp.) species since 1987 in soybean fields in China (Winston et al. 2014). Similarly, the bioherbicide "Woad Warrior" with the active ingredient Puccinia thlaspeos has been approved to control Isatis spp. in the USA (Cordeau et al. 2016, Lovic et al. 1988). It is also stated that populations of some weed species can be kept under control in agricultural areas by promoting (natural biological control) fungal pathogens affecting weeds (Atay et al. 2015, Özer et al. 2001, Sırrı and Özaslan 2022). These studies reveal that at least some of the pathogens affecting weeds in natural or agricultural ecosystems have the potential to be used as biocontrol agents. Therefore, the determination of fungal agents on weeds and their effectiveness in agriculture and non-agricultural areas can contribute significantly to the creation of integrated weed control strategies.

Ecological and biological diversity in Türkiye naturally affects microfungi biota and causes significant regional differences in fungal species on weeds and their effectiveness. Therefore, fungal pathogens affecting weed populations show significant spatial and temporal differences in the country (Bahcecioglu and Gjaerum 2003, Demirci et al. 1997, Doğan 2013, Ekici et al. 2012, Erciş 1989, Erdogdu et al. 2010, Erdogdu and Hüseyin 2013, Erper et al. 1997, Kabaktepe 2010, Kirbağ 2004, Özaslan 2011, Özaslan et al. 2013, Özaslan et al. 2015, Sert and Sümbül 2003, Sert 2009, Tunalı et al. 2009, Ulukapı 2016).

Yüksekova Basin in Hakkari province has been considered an important location for potential biological control agents due to its rich and undisturbed flora and fauna, a continuation of traditional agricultural practices, and limited use of pesticides and chemical fertilizers. Therefore, this study aimed to determine the weeds and microfungi on the weeds in the Yüksekova Basin over areas that are used in different ways (agricultural and non-agricultural).

MATERIALS AND METHODS

The study area is located in the Yüksekova district of Hakkari province. The basin is a depression plain surrounded by mountains. The altitude of the plain is between 1950 and 2000 m, its width is 15 km, and its length is 40 km. The region has a generally harsh continental climate due to its altitude and location.

Field studies (surveys) were carried out in 2020 – 2021 to determine the weed species and fungal agents on the weeds. The basin was divided into a 1 × 1 km grid, and 232 points were selected to represent the study area. Surveys were carried out in 4 different periods from the emergence of weeds in the spring to the end of the vegetation period (i.e., May through September). Weeds showing visible signs of disease were detected by surveying an area of 50 m × 50

Table 1. Host weed species and observed microfungi

Genus	Microfungi Species	Host Weed Species
Alternaria	*Alternaria alternariae* (Cooke) Woudenb. & Crous	*Rumex crispus* L.
	Alternaria alternata (Fr.) Keissl.	*Polygonum amphibium* L., *Rumex conglomeratus* Murray
	Alternaria aspera Woudenb. & Crous	*Plantago lanceolata* L.
	Alternaria atra (Preuss) Woudenb. & Crous	*Cerinthe minor* L. subsp. *auriculata* (Ten.) Domac, *Convolvulus arvensis* L., *Salvia verticillata* L. subsp. *verticillata, Ranunculus diversifolius* Boiss. & Kotschy
	Alternaria botrytis (Preuss) Woudenb. & Crous	*Chenopodium album* L. subsp. *album var. album, Senecio doriiformis* DC. subsp. *doriiformis, Medicago sativa* L. subsp. *sativa*
	Alternaria chartarum Preuss	*Equisetum arvense* L., *Calamagrostis epigeios* (L.) Roth
	Alternaria consortialis (Thüem.) W. Groves & S. Hughes.	*Tanacetum balsamitoides* Sch. Bip., *Dactylis glomerata* L. subsp. *glomerata, Ranunculus flammula* L.
	Alternaria dianthicola Weerg.	*Silene vulgaris* (Moench) Garcke var. *vulgaris, Plantago major* L. subsp. *intermedia* (Gilib.) Lange
	Alternaria herbiphorbicula E.G. Simmons	*Cirsium haussknechtii* Boiss., *Dipsacus laciniatu* L., *Silene vulgaris* (Moench) Garcke var. *vulgaris, Nepeta nuda* subsp. *albiflora* (Boiss.) Gams
	Alternaria hispidula Ellis	*Artemisia absinthium* L., *Euphorbia cheiradenia* Boiss. & Hohen., *Medicago sativa* L. subsp. *sativa, Hypericum perforatum* L. subsp. *veronense* (Schrank) H.Linb., *Rumex crispus* L.
	Alternaria lanuginosa (Harz.) Sacc.	*Eryngium campestre* L. var. *virens* Link, *Cichorium intybus* L., *Scorzonera veratrifolia* Fenzl, *Plantago lanceolata* L.
	Alternaria loliicola Meng Zhong	*Lolium perenne* L.
	Alternaria microspora (Moub. & Abbel-Hafez) Gannibal & D.O. Lawr.	*Inula britannica* L.
	Alternaria multiformis (E.G. Simmons) Woudenb. & Crous.	*Inula britannica* L.
	Alternaria obovoidea (E.G. Simmons) Woudenb. & Crous	*Rumex conglomeratus* Murray
	Alternaria oudemansii (E.G. Simmons) Woudenb. & Crous	*Carex distans* L. subsp. *distans*
	Alternaria tenuissima (Kunze) Wiltshire	*Stachys annua* L. subsp. *annua*
	Alternaria septospora (Preuss.) Woudenb. & Crous	*Chenopodium album* L. subsp. *album* var. *album, Anchusa azurea* Mill. var. *azurea, Nepeta nuda* subsp. *albiflora* (Boiss.) Gams. *Alcea striata* (DC.) Alef. subsp. *striata*
Curvularia	*Curvularia lunata (Wakker) Boedijn*	*Cirsium haussknechtii* Boiss.
	Curvularia sorghina R.G. Shivas & Sivan.	*Sorghum halepense* (L.) Pers. var. *halepense*
	Curvularia protuberata Nelson & Hodges	*Stachys annua* L. subsp. *annua*
	Curvularia trifolii (Kauffm.) Boedijn	*Sanguisorba officinalis* L.
Pirenofora	*Brachysporium gracile* (Wallr.) Sacc.	*Convolvulus arvensis* L.
Macrosporium	*Macrosporium malvae* Thüem.	*Alcea striata* (DC.) Alef. subsp. *striata*
Stemphylium	*Stemphylium piriforme* Bon.	*Echinops spinosissimus* Turra subsp. *bithynicus* (Boiss.) Greuter., *Inula britannica* L., *Epilobium hirsutum* L.
	Stemphylium vesicorium (Wallk) E.G. Simmons	*Urtica dioica* L. subsp. *dioica*
Periconia	*Periconia funerea* (Ces.) Mason & M.B. Ellis	*Hordeum bulbosum* L.
Dendryphion	*Dendriphion camosum* Wallr.	*Stachys annua* L., *Polygonum amphibium* L.
Stagonospora	*Dictyoartrinium sacchari* (J.A. Stev.) Damon	*Anchusa azurea* Mill. var. *azurea*

Aecidium	*Aecidium eremostachydis* Petr.	*Phlomoides laciniata* (L.) Kamelin & Makhm.
Uromyces	*Aecidium polygoni-cuspidati* Diet.	*Polygonum aviculare* L.
	Uromyces chenopodii (Duby) Schroet.	*Chenopodium album* L.
	Uromyces epilobii (DC.) Lév.	*Epilobium hirsutum* L.
	Uromyces fischeri-eduardi Magn.	*Vicia tetrasperma* (L.) Schreb.,*Vicia cracca* L. subsp. *cracca*
	Uromyces glycyrrhizae (Rab.) Magn.	*Glycyrrhiza glabra* L. var. *glabra*
	Uromyces gypsophilae Cooke	*Vaccaria hispanica* (Mill.) Rauschert
	Uromyces ononidis Pass.	*Ononis spinosa L. subsp. leiosperma* (Boiss.) Sirj.
	Uromyces pisi (Pers.) de By	*Lathyrus tuberosus* L.
	Uromyces polygoni-avicularae (Pers.) P. Karsten	*Polygonum aviculare* L.
	Uromyces rumicis (Schum.) Wint.	*Rumex crispus* L.
	Uromyces scillarum (Grev.) Wint.	*Bellevalia paradoxa* (Fisch. & C.A. Mey.) Boiss.
	Uromyces sp.	*Centaurea nemecii* Nábělek
	Uromyces striatus J. Schroet.	*Medicago sativa* L. subsp. *sativa*
	Uromyces tuberculatus Fuckel	*Euphorbia cheiradenia* Boiss. & Hohen.
	Uromyces turcomanicum Katajev	*Hordeum bulbosum* L.
Melampsora	*Melampsora euphorbiae* (Ficinus & Schubert) Castagne, 1843	Euphorbia heteradena Jaub. & Spach
Phragmidium	*Phragmidium sanguisorbae* (DC.) J. Schröt., 1889.	*Sanguisorba minor* L. subsp. *minor*
Puccinia	*Puccinia acarnae* Syd.	*Picnomon acarna* (L.) Cass.
	Puccinia centaurea DC.	*Centaurea iberica* Trev. ex Spreng.
	Puccinia chaerophylli Purton	*Chaerophyllum crinitum* Boiss.
	Puccinia chondrillina Bub. & Syd.	*Chondrilla juncea* L.
	Puccinia cichorii (DC.) Belynck	*Cichorium intybus* L.
	Puccinia cnici Mart.	*Cirsium haussknechtii* Boiss.
	Puccinia cyani (Schleich.) Pass.	*Centaurea gigantea* Sch.Bip. ex Boiss.,*Centaurea nemecii* Nábělek
	Puccinia echinopis DC.	*Echinops spinosissimus* Turra subsp. *bithynicus* (Boiss.) Greuter
	Puccinia falcariae (Pers.) Fuckel	*Falcaria vulgaris* Bernh.
	Puccinia ganeschinii Tranz. & Erem.	*Rhaponticum repens* (L.) Hidalgo
	Puccinia graminis Pers.	*Triticum aestivum* L.
	Puccinia isiacae (Thüem.) Wint.	*Isatis tinctoria* L., *Hyoscyamus niger* L.
	Puccinia jaceae Otth.	*Centaurea behen* L.
	P*uccinia lojkaiana* Thüem.	*Bellevalia paradoxa* (Fisch. & C.A.Mey.) Boiss.
	Puccinia mabvacearum Mont.	*Alcea striata* (DC.) Alef. subsp. *striata*
	Puccinia magnusiana Koern.	*Phragmites australis* (Cav.) Trin. ex Steud.
	Puccinia nigrescens Kirch.	*Salvia verticillata* L. subsp. *verticillata*
	Puccinia opopanacis Ces.	*Opopanax hispidus* (Friv.) Griseb.
	Puccinia polygoni Alb. & Schw.	*Polygonum amphibium* L.
	Puccinia polygoni-amphibii Pers	*Polygonum amphibium* L.
	Puccinia pozzii Semadeni	*Chaerophyllum crinitum* Boiss.
	Puccinia praegracilis Arthur	*Dactylorhiza umbrosa* (Karelin & Kirilow) Nevski var. *umbrosa*
	Puccinia punctata Link	*Galium verum* L. subsp. *verum*
	Puccinia ranunculi Blytt	*Ranunculus arvensis* L.
	Puccinia schirajewskii Tranz.	*Klasea radiata* (Waldst. & Kit.) A. Löve & D. Löve subsp. *biebersteiniana* (Grossh.) Greuter
	Puccinia stipina Tranz.	*Salvia verticillata* L. subsp. *verticillata*
	Puccinia taraxsaci (Reb.) Plowr.	*Tanacetum balsamitoides* Sch. Bip.
	Puccinia tiflisensis Petr.	*Cirsium arvense* (L.) Scop.
	Puccinia vagans (DC.) Arth.	*Epilobium hirsutum* L.
Cintractia	*Cintractia caricis* (Pers.) Magn.	*Carex distans* L. subsp. *distans*
Coniothecium	*Coniothecium seriale* Durieau & Mont.	*Falcaria vulgari* Bernh., *Equisetum arvense* L.
Annellophorella	*Annellophorella foureae* (Henn.) M.B. Ellis	*Inula britannica* L.
Dicoccum	*Dicoccum asperum* (Corda) Sacc.	*Lactuca scarioloides* Boiss.

	Ramularia rubella (Bon.) Nannf.	*Falcaria vulgaris* Bernh.
	Ramularia armoraciae Fuckel	*Raphanus raphanistrum* subsp. *raphanistrum* L.
	Ovularia ovata (Fuckel) Sacc.	*Tanacetum balsamitoides* Sch. Bip.
Ramularia	*Ramularia menthicola* Sacc.	*Mentha longifolia* (L.) L. subsp. *typhoides* (Briq.) Harley
Cercospora	*Cercospora megidicaginis* Ell. & Ev.	*Medicago sativa* L. subsp. *sativa*
Cladosporium	*Cladosporium fasciculare* (Pers.) Fr.	*Sanguisorba officinalis* L.
Taeniolella	*Taeniolella plantaginis* (Corda) Hughes	*Bellevalia paradoxa* (Fisch. & C.A. Mey.) Boiss., *Anchusa azurea* Mill. var. azurea
Sporidesmium	*Sporidesmium cladosporii* Corda	*Acanthus dioscoridis* L. var. *dioscoridis, Cirsium arvense* (L.) Scop., *Xanthium strumarium* L. subsp. *strumarium*
Sporidesmium	*Sporidesmium microscopicum*	*Lysimachia vulgaris* L.
Brachysporium	*Brachysporium flexuosum* (Corda) Sacc.	*Pulicaria dysenterica* (L.) Bernh. subsp. *dysenterica*
Coniosporium	*Coniosporium rhizophilum* (Preuss) Sacc.	*Cerinthe minor* L. subsp. *auriculata* (Ten.) Domac
	Coniosporium triticinum L. Gaja	*Lysimachia vulgaris* L.
Scolicotrichum	*Scolicotrichum bonordenii* Sacc.	*Lepidium draba* L.
Trichothecium	*Trichothecium roseum* (Pers.) Link.	*Trifolium repens* L. var. *repens*
Geotrichum	*Oospora lactis* (Fres.) Sacc.	*Nepeta betonicifolia* C.A. Mey. subsp. *betonicifolia*
Bostrichonema	*Bostrichonema alpestre* Ces.	*Phlomoides laciniata* (L.) Kamelin & Makhm.
Diplocarpon	*Diplocarpon alpestre* Ces.	*Polygonum amphibium* L.
Entyloma	*Entyloma crastophilum* Sacc.	*Lolium perenne* L.
Hadrotrichum	*Hadrotrichum sorghi* (Pass.) Ferraris & Massa.	*Sorghum halepense* (L.) Pers. var. *halepense*
Botryotrichum	*Botryotrichum atrogriseum* J.F.H. Beymo	*Rumex conglomeratus* Murray
Physoderma	*Physoderma menthae* J. Schrot.	*Mentha longifolia* (L.) subsp. *typhoides* (Briq.) Harley

m at each sampling point. These plants were accepted as microfungus hosts and their samples with disease symptoms were taken to the herbarium.

In the laboratory, samples were taken from the diseased parts of the host weeds (herbarium specimens), and isolation procedures were performed (Özaslan 2011).

The preparations obtained from pure fungal cultures and the preparations made by scraping (obligate fungi) were examined under the microscope for the identification of microfungi at the genus level. The lesions in plant tissue and features such as conidial structures, branching of the conidiophore, conidia structure, conidia shape, and size were taken into consideration in genus-level diagnoses (Ellis and Ellis 1985, Gannibal and Lawrence 2018a, Gannibal and Lawrence 2018b, Shvartsman et al. 1973). The species-level identification of the fungi samples/properties was made by Retired Professor Elşad Hüseyin (Ahi Evran University, Faculty of Arts and Sciences, Department of Biology). The host weed species were identified using plant specimens in the herbarium of the Plant Flora Laboratory (Siirt University Faculty of Arts and Sciences) and different books related to Turkish flora (Flora of Turkey Davis 1965–1985, Önen 2015, Özer et al. 1996, Özer et al. 1998, Özer et al. 1999, Serin 2008). Identified weed samples approved by Ass. Prof. Dr. Mehmet Fidan (Siirt University Faculty of Arts and Sciences, Biology Department).

RESULTS

A total of 220 plant samples belonging to 79 weed species were collected from the study area. Weed species observed in the study area belonged to 29 different families. Similarly, 101 microfungi (leaf pathogen and obligate) species infecting weeds were observed in the region. Weed and microfungi species recorded from the study area are given in Table 1.

The weed families hosting the highest number of fungi were *Asteraceae* (20 species), *Fabaceae* (7 species), *Poaceae* (7 species), and *Lamiaceae* (6 species). The microfungi detected on weeds belonged to *Puccinia* (29 species), *Alternaria* (18 species), *Uromyces* (14 species), and *Curvularia* (4 species). A total of 84 microfungi species (e.g. *Puccinia chondrillina*, *P. cnici*, *P. magnusiana*, *P. cyani*, *P. falcariae*, *Stemphylium vesicorium*, and *Uromyces polygoni-avicullariae*) determined just on a single weed in the region. The remaining 17 species (e.g. *Alternaria atra*, *A. alternata*, *A. botrytis*, *A. chartarum*, *A. consortialis*, *A. dianthicola*, *A. herbiphorbicula*, *A. hispidula*, *A. lanuginosa*, *A. septospora*, *Coniothecim seriale*, *Dendryphion comosum*, *Puccinia cyani*, *P. isiacae*, *Taeniolella plantaginis*, *Sporidesmium cladosporii*, and *Stemphylium piriforme*) were found on more than one weed species

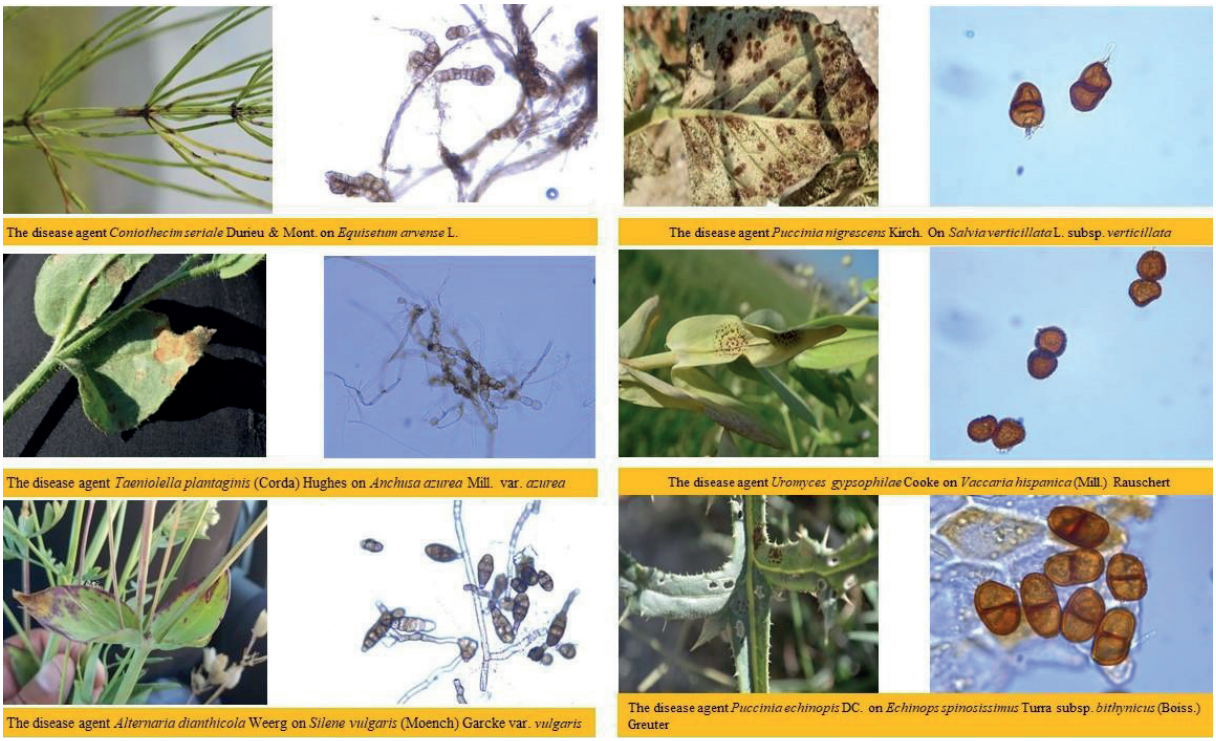

Figure 1. Examples of host weed species and observed microfungi

DISCUSSION AND CONCLUSION

A total of 101 microfungi species were identified from 79 weed species in the Yüksekova basin. It was determined that most of the recorded microfungi species belonged to Alternaria, Puccinia, and Uromyces genera. These are the most common genera in the microfungi biota found on weeds in different regions of Türkiye (Asav et al. 2015, Doğan 2013, Ekici 2011, Erciş and İren 1988b, Erciş and İren 1993, Ertuğrul et al. 2019, Kabaktepe 2010, Özaslan 2011, Özaslan et al. 2013, Özaslan et al. 2015, Özaslan 2016, Sırrı and Özaslan 2022, Ulukapı 2016, Uygun et al. 1994, Uygur et al. 1993). Therefore, the results are in agreement with previous studies. However, it has been determined from field observations that microfungi highly limit the vegetative growth of many weed species in the basin. It has been observed that some microfungi species cause high deformations in the flower, leaf, and stem of host weed species, limit plant growth, and even cause death. For instance, it was observed that Cercospora convolvulicola and Curvularia inaequalis species significantly inhibited the growth and development of Polygonum amphibium under field conditions and suppressed the population density of the weed. Similarly, the development and population density of Anchusa azurea, Salvia verticillata and Galium verum were significantly affected by Dendryphion comosum, Taeniolella plantaginis, and Puccinia punctata, respectively. It was concluded that the effectiveness of microfungi was at the highest level due to the limited use of pesticides and the continuation of traditional agricultural practices in the basin. It has also been stated in previous studies that the activities of microfungi can be increased, especially by reducing the use of pesticides and supporting beneficial organisms in the field, and can contribute to integrated weed control in organic farming (Önen and Kara 2008, Önen 2014).

The activity of some fungal species such as monophage Uromyces polygoni-avicullariae, Puccinia chondrillina, and P. cnici reached significant levels in the study area. These species have been used in the biological control of weeds such as Chondrilla juncea, Cirsium sp., and Polygonum bellardii (Espiau et al. 1997, Michaux 1984). P. chondrillina used in the management of C. juncea in Australia is among the most successful examples of fungi used as a biocontrol agent (Cullen 1976). Besides, different species in these genera can also be used successfully in the biological control of weeds. P. xantii (Julien et al. 1979, Uygun et al. 1994), Phytophthora palmivora (Kenney 1986), Phragmidium violaceum (Adams 1988), Colletotrichum gloeosporioides f. sp. aeschynomene (Kumar 1992) and Ulocladium atrum (Linke et al. 1992) fungi species can be used successfully for the biological control of Xanthium strumarium, Merrenia odorata, Rubus spp., Aeschynomene virginica and Orobanche spp. weed species, respectively. Considering these successful examples, it was concluded that the monophagous fungal species detected in the study area should be evaluated in terms of

biological activity. It is reported that the host-specific P. cyani detected on Centaurea gigantea and endemic C. nemeci in the study area has the potential to be used in the biological control of Centaurea species (Ulukapı 2016). Similarly, it has been reported that P. chordrillina can be extremely effective in the control of C. juncea (Erciş and İren 1988a, Erciş and İren 1993, Nemli 1991).

In conclusion, the results revealed the presence of some promising pathogens. However, to determine the potential of the identified biocontrol agents as myco-herbists; detailed laboratory, greenhouse, and field trials as well as host tests and efficacy studies are required. Moreover, detailed survey studies should be conducted in the future. Observations in the basin have shown that natural biological control can be extremely effective in the region and that some important weed species can be suppressed by microfungi. Although biological control alone is not sufficient for weed management in agricultural production areas throughout the basin, microfungi can play an important role within the scope of integrated control. Therefore, it would be appropriate to adopt and expand organic/good agricultural practices, which aim to protect and support the beneficial organisms in agricultural production, in the region. Thus, both the sustainable use of chemical fertilizers and pesticides and the protection of human/environmental health in the region will be possible, and crop pests, diseases, and weeds will be successfully managed.

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ÖZET

Önemli ekolojik, ekonomik ve sağlık sorunlarına neden olan yabancı otların sürdürülebilir bir yönetimi için biyolojik mücadele çalışmaları giderek daha fazla ilgi görmektedir. Hedef yabancı ot türleri üzerindeki potansiyel biyolojik mücadele ajanlarının (zararlılar, patojenler vb.) tespiti biyolojik mücadelenin ilk adımıdır ve türün biyolojik mücadelesi için temel bilgiler sağlar. Bu çalışmada Hakkari/Yüksekova havzasında zararlı yabancı otlar üzerinde bulunan mikrofungus türlerin belirlenmesi amaçlanmıştır. Bölgede geleneksel tarımsal uygulamaların devam etmesi, ilaç ve kimyasal gübrelerin çok az kullanılması veya hiç kullanılmaması, doğal flora/faunanın Türkiye'nin diğer bölgelerine göre nispeten daha iyi korunması gibi nedenler çalışma alanının seçiminde rol oynamıştır. Çalışma alanında 2020 ve 2021 yıllarında farklı dönemlerde yürütülen sürvey çalışmaları sonucunda; 29 familyaya ait toplam 79 yabancı ot türü üzerinde 101 mikrofungus türü tespit edilmiştir. Havzada en sık rastlanan fungus türlerinin *Puccinia* (29 tür), *Alternaria* (18 tür), *Uromyces* (14 tür) ve *Curvularia* (4 tür) cinslerine dahil oldukları saptanmıştır. Söz konusu fungus türlerine konukçuluk yapan yabancı ot türlerinin ise en fazla Asteraceae (20 tür), Fabaceae (7 tür), Poaceae (7 tür) ve Lamiaceae (6 tür) familyalarına ait oldukları belirlenmiştir. Çalışmada, sadece tek konukçu (yabancı ot) üzerinde 84 mikrofungus türü tespit edilirken, geri kalan 17 tür ise birden fazla yabancı ot türü üzerinde tespit edilmiştir. Çalışmada *Puccinia cyani* (Schleich.) Pass., *Puccinia chondrillina* Bub. & Syd., *Uromyces polygoni-avicularіae* (Pers.) P. Karsten gibi bazı fungus türlerinin konukçu yabancı ot türlerinin (sırasıyla *Centaurea* spp., *Chondrilla juncea* L., *Polygonum aviculare* L.) gelişimini önemli ölçüde engelledikleri ve popülasyonlarını baskılayabildikleri gözlemlenmiştir. Sonuçlar, tespit edilen patojenlerin biyolojik aktivite açısından gözden geçirilmesi ve bölgede detaylı saha çalışmalarının yapılmasının faydalı olacağını ortaya koymuştur.

Anahtar kelimeler: biyolojik mücadele, yabancı ot, mikrofungus, Yüksekova havzası, Hakkâri, Türkiye

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