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ARTICLE

Occurrence and Identification of Common Fungal Diseases of Cultivated Sea Buckthorn (*Hippophae rhamnoides* L.) in Mongolia

Odonmandal Gombodorj[1,2*], Gantuya Myagmarsaikhan[1], Ariunaa Saraadanbazar[1], Tseveendorj Dalkhaa[1], Narantsatsralt Davaadorj[1], and Byambasuren Mijidsuren[1]

[1] Institute of Plant Protection Research, 123/6 Enkhtaivan Avenue, 13th District, Bayanzurkh District, Ulaanbaatar-13330, Mongolia
[2] Mongolian University of Life Sciences, Zaisan, 22th khoroo, Khan-Uul district, Ulaanbaatar-17029, Mongolia

*Corresponding author: odonmandalg@gmail.com

https://orcid.org/0009-0004-7086-4442

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Abstract
Sea buckthorn (*Hippophae rhamnoides* L.) is widely cultivated in Mongolia as part of national programs aimed at expanding fruit and berry production. However, fungal diseases increasingly threaten fruit yield, quality, and sustainable production. Therefore, we investigated the fungal diseases commonly occurring in sea buckthorn cultivated in Mongolia. This study aimed to identify the major fungal pathogens affecting cultivated sea buckthorn in selected provinces of Mongolia and the vicinity of Ulaanbaatar. Field surveys were conducted during 2023–2024 at 11 sites in Tuv, Selenge, Khuvsgul, and Bulgan provinces, as well as around Ulaanbaatar. Symptomatic plant samples were collected and examined using morphological and microscopic methods. Fungal pathogens were isolated on potato dextrose agar (PDA), and pure cultures were identified using standard fungal identification keys. Three major fungal diseases were identified: Verticillium wilt caused by *Verticillium dahliae* (36.36%), Fusarium dried-shrink caused by *Fusarium sporotrichioides* (27.27%), and brown rot caused by *Monilia altaica* (27.27%). Brown spot caused by *Alternaria* sp. was detected in 9.09% of samples. Pure cultures of the major pathogens were successfully isolated and taxonomically classified. The findings indicate that Verticillium wilt, Fusarium dried-shrink, and brown rot are the most common fungal diseases of cultivated sea buckthorn in the surveyed regions of Mongolia. These results provide baseline information for future disease monitoring and support the development of sustainable disease management strategies, including biological control approaches.

Keywords: Verticillium wilt, Brown rot, Fusarium wilt, disease prevalence

Introduction

Sea buckthorn (*Hippophae rhamnoides* L.) is a valuable perennial shrub widely recognized for its nutritional, medicinal, and ecological importance. Its fruits contain more than 190 biologically active compounds, including vitamins, carotenoids, flavonoids, organic acids, and essential fatty acids, making it an important resource for the food, pharmaceutical, and cosmetic industries [1]. In addition to its economic value, sea buckthorn contributes to soil conservation, erosion control, and ecological restoration through its extensive root system and ability to improve soil fertility, particularly in temperate and semi-arid regions [2]. pathogens represent the most important group. Previous studies conducted in Mongolia have indicated that approximately 80% of infectious

In Mongolia, the cultivation of sea buckthorn has expanded considerably over the past two decades following the implementation of the national "Sea Buckthorn" and "Fruits and Berries" programs, which aimed to increase domestic fruit production, improve food security, reduce imports, and enhance export opportunities [3, 4]. As a result, the area under cultivation and overall production of sea buckthorn have increased substantially. However, the expansion of cultivation has also increased the occurrence and spread of plant diseases, creating new challenges for sustainable production. Among the diseases affecting sea buckthorn, fungal diseases of fruit and berry crops are caused by fungi [5], with several major fungal diseases frequently occurring in sea buckthorn plantations. Common

pathogens include *Fusarium* spp., which cause root rot and plant decline; *Verticillium* spp., responsible for vascular wilt; and other fungi associated with fruit, stem, and root rot, including *Alternaria*, *Botrytis*, and *Pythium* species [6].

Among these diseases, Verticillium wilt caused by *Verticillium dahliae* is considered one of the most destructive. As a soil-borne pathogen, *V. dahliae* infects the vascular tissues of the host plant, disrupting water transport and causing chlorosis, wilting, branch dieback, and, ultimately, plant death [7, 8]. The persistence of microsclerotia in soil and the broad host range of the pathogen make disease management particularly difficult.

Despite the increasing economic importance of sea buckthorn cultivation in Mongolia, information on the distribution and prevalence of fungal pathogens in commercial plantations remains limited. Comprehensive surveys are needed to identify the dominant pathogens and assess their occurrence in different production regions. Such information is essential for the development of effective disease management strategies, including environmentally friendly biological control approaches.

Therefore, the objective of this study was to identify the major fungal pathogens associated with cultivated sea buckthorn plantations in Mongolia and to evaluate their prevalence across different provinces. We hypothesized that *Verticillium*, *Fusarium*, and *Monilia* species are among the dominant fungal pathogens affecting cultivated sea buckthorn. The results provide baseline information for future disease monitoring and the development of biological control strategies.

Materials and Methods

Study Area and Sample Collection

Field surveys were conducted during 2023–2024 as part of the "Research on Forest Trees and Shrubs" project. Samples were collected from sea buckthorn (*Hippophae rhamnoides* L.) plantations located in Khuvsgul, Bulgan, Tuv, and Selenge provinces, as well as from urban green spaces in the vicinity of Ulaanbaatar, Mongolia (Figure 1). Plants exhibiting disease symptoms [9], including leaf discoloration, wilting, necrosis, stem lesions, dieback, and fruit rot, were selected for sampling [10]. Symptomatic tissues, including leaves, stems, branches, roots, and fruits, were collected and placed in labeled paper bags for transport to the laboratory. For each sampling site, information on geographic location, vegetation type, soil conditions, and surrounding plant communities was recorded. Geographic coordinates were mapped using ArcGIS software.

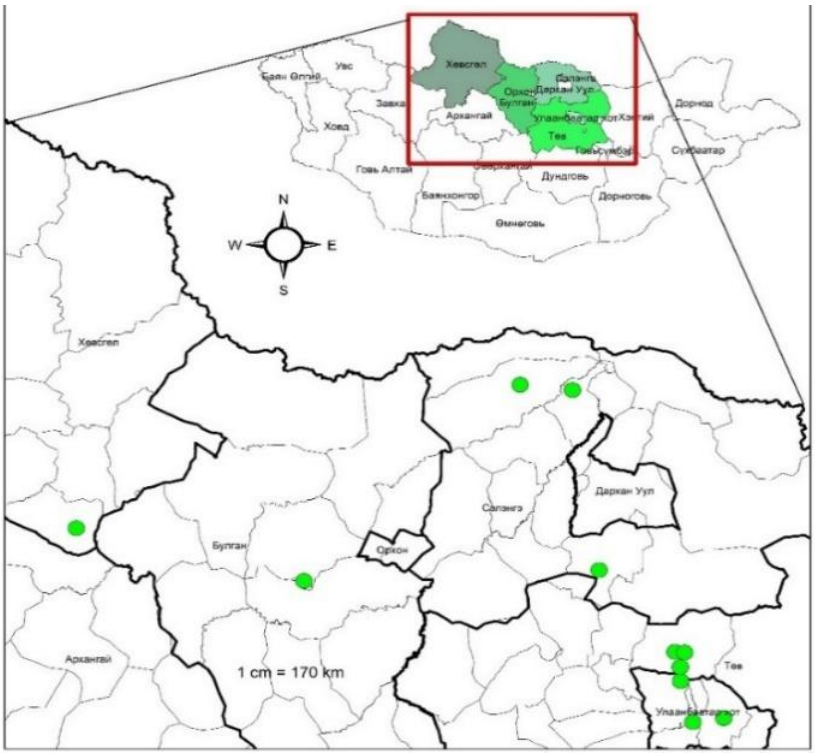

Figure 1. Geographic distribution of the 11 sampling sites surveyed for fungal diseases of cultivated sea buckthorn (*Hippophae rhamnoides* L.) in Mongolia during 2023–2024. Green circles indicate sampling locations. The inset map shows the location of the study area within Mongolia.

Isolation and Culturing of Fungal Pathogens

To induce fungal growth, infected plant tissues were first incubated in moist chambers [11]. Petri dishes lined with sterile filter paper moistened with distilled water were prepared. Plant samples were surface sterilized in 70% ethanol for 1–2 min, rinsed with sterile distilled water, and placed in the moist chambers. The dishes were sealed and incubated at 25–27 °C. Fungal growth typically appeared within 48 h [12].

Emerging fungal colonies were transferred onto potato dextrose agar (PDA) medium and incubated at 25 °C. Pure cultures were obtained through two to three successive subcultures. Colony morphology, including growth rate, colony color, texture, margin characteristics, aerial and submerged mycelium development, and spore morphology, was recorded. Fungal isolates were identified using standard taxonomic keys and fungal identification manuals [5] .

Healthy plant tissues collected from the same sampling sites were processed under identical laboratory conditions and served as controls to verify that fungal growth originated from infected tissues. All isolation procedures were performed in triplicate.

Statistical Analysis

The prevalence of fungal diseases was expressed as the proportion of infected samples among the total number of samples examined. The 95% confidence intervals (CIs) for disease prevalence were calculated using the Clopper–Pearson exact method, which is based on the binomial distribution.

This approach provides exact confidence limits for proportions and is particularly suitable for prevalence data derived from finite sample sizes [13].

Results

Occurrence of Fungal Diseases in Sea Buckthorn Plantations

Field surveys conducted during 2023–2024 covered cultivated sea buckthorn (*Hippophae rhamnoides* L.) plantations in Bulgan, Selenge, Tuv, and Khuvsgul provinces, as well as the vicinity of Ulaanbaatar. A total of 11 symptomatic samples were collected and examined in the laboratory. Disease diagnosis was based on symptom characteristics, fungal colony morphology, and microscopic observations. The identified diseases, associated pathogens, and sampling locations are summarized in Table 1.

Table 1.

Sampling locations, disease symptoms, and fungal pathogens identified from cultivated sea buckthorn (*Hippophae rhamnoides* L.) plantations in Mongolia

No.	Sampling location	Coordinates (N, E)	Observed symptoms	Disease and pathogen
1	Gunt, Songinokhairkhan District, Ulaanbaatar	48.089027, 106.817255	Fruits covered with small black spots	Fusarium wilt (*Fusarium* sp.)
2	Bulgan soum, Bulgan Province	48.846475, 103.481735	Fruit shriveling and branch dieback	Brown rot (*Monilia altaica*)
3	Bayangol soum, Selenge Province	48.854860, 106.066133	Fruit shriveling and branch blackening	Fusarium wilt (*Fusarium* sp.)
4	Tsagaannuur soum, Selenge Province	50.109158, 105.443488	Brown spots on leaves	Brown spot (*Alternaria* sp.)
5	Zuunburen soum, Selenge Province	50.072651, 105.893555	Fruit shriveling and branch blackening	Verticillium wilt (*Verticillium* sp.)
6	West 4th Road, Ulaanbaatar	48.619628, 106.381463	Leaf yellowing with black spots	Verticillium wilt (*Verticillium* sp.)
7	Rashaant, Khuvsgul Province	49.123752, 101.441307	Fruit discoloration and decay	Brown rot (*Monilia* sp.)

8	Batsumber soum, Tuv Province	48.285184, 106.743928	Brown lesions on leaves	Fusarium wilt (*Fusarium* sp.)
10	Batsumber soum, Tuv Province	48.387494, 106.809170	Fruit desiccation and branch dieback	Brown rot (*Monilia* sp.)
11	Shar Khooloi, Gachuurt, Ulaanbaatar	47.928146, 107.157798	Lower branches defoliated, upper canopy bearing leaves and fruits	Verticillium wilt (*Verticillium* sp.)

Four fungal diseases were identified among the 11 symptomatic sea buckthorn samples collected during the survey (Table 1). Verticillium wilt caused by Verticillium spp. was the most frequently detected disease, occurring in 4 samples (36.36%). Fusarium wiltcaused by Fusarium spp. and brown rot caused by Monilia spp. were each detected in 3 samples (27.27%), while brown spot caused by Alternaria spp. was identified in 1 sample (9.09%).

The prevalence of each disease and the corresponding 95% confidence intervals estimated using the Clopper–Pearson exact method are presented in Figure 2. Overall, Verticillium, Fusarium, and Monilia species were the dominant fungal pathogens associated with cultivated sea buckthorn plantations in the surveyed regions of Mongolia.

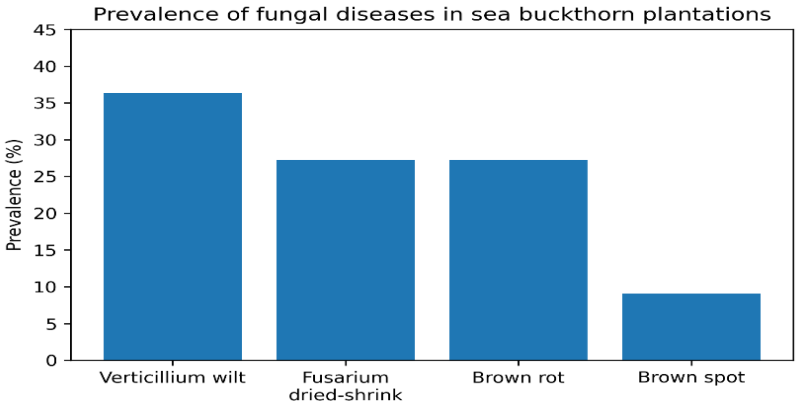

Figure 2. Prevalence (%) of fungal diseases identified in cultivated sea buckthorn plantations in Mongolia during 2023–2024. Error bars represent 95% confidence intervals calculated using the Clopper–Pearson exact method.

Isolation and Identification of Fungal Pathogens

Pure fungal cultures were successfully isolated from symptomatic sea buckthorn tissues collected during the field surveys. Based on colony morphology, microscopic characteristics, and taxonomic identification keys, three major fungal pathogens were identified: *Fusarium sporotrichioides*, *Verticillium dahliae*, and *Monilia altaica* (Table 2).

Table 2.

Taxonomic classification of fungal pathogens isolated from cultivated sea buckthorn plantations.

Taxonomic rank	***Fusarium sporotrichioides***	***Verticillium dahliae***	***Monilia altaica***
Kingdom	Fungi	Fungi	Fungi
Phylum	Ascomycota	Ascomycota	Ascomycota
Class	Sordariomycetes	Sordariomycetes	Leotiomycetes
Order	Hypocreales	Hypocreales	Helotiales
Family	Nectriaceae	Plectosphaerellaceae*	Sclerotiniaceae
Genus	*Fusarium*	*Verticillium*	*Monilia*
Species	*F. sporotrichioides*	*V. dahliae*	*M. altaica*

*Taxonomy according to current fungal classification.

Taxonomic analysis showed that all isolated pathogens belonged to the phylum *Ascomycota*. The isolates were classified into two classes (*Sordariomycetes* and *Leotiomycetes*), three orders, and three families (Table 2). Among the identified pathogens, *Fusarium sporotrichioides* and *Verticillium dahliae* belonged to the class *Sordariomycetes*, whereas *Monilia altaica* belonged to the class *Leotiomycetes*.

Distinct colony morphologies were observed after 7 days of incubation on PDA medium (Figure 3). *Fusarium* isolates exhibited rapid growth and produced pink colonies with concentric pigmentation. *Verticillium* isolates formed light-colored colonies with radial growth patterns and irregular margins. *Monilia* isolates developed dark gray to brown colonies with a wrinkled surface texture (Figure 3). Colonies of *Fusarium sporotrichioides* exhibited rapid growth with pink pigmentation and concentric ring-like structures. *Verticillium dahliae* produced light-colored colonies with radial growth patterns and irregular margins. Colonies of *Monilia altaica* were characterized by a dark brown to grayish coloration and a wrinkled surface texture.

Microscopic examination revealed characteristic spore morphologies that supported species identification (Figure 4). Disease symptoms associated with these pathogens included leaf wilting and curling, branch dieback, fruit discoloration, fruit shriveling, and partial canopy decline (Figure 5).

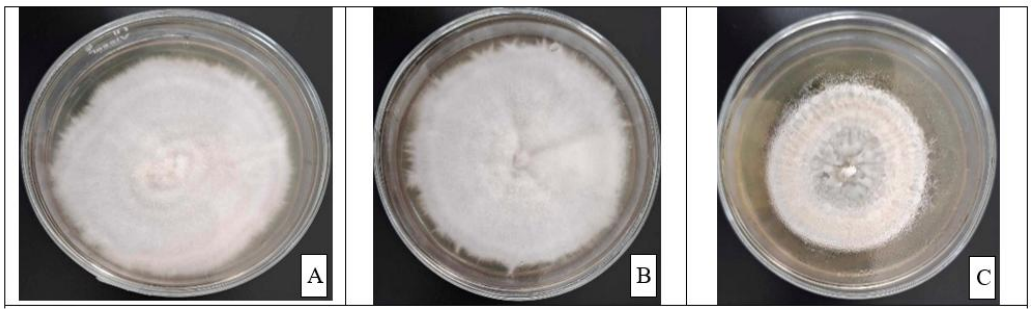

Figure 3. Colony morphology of fungal pathogens isolated from sea buckthorn after 7 days of incubation on PDA medium. (A) *Fusarium* sp.; (B) *Verticillium* sp.; (C) *Monilia* sp.

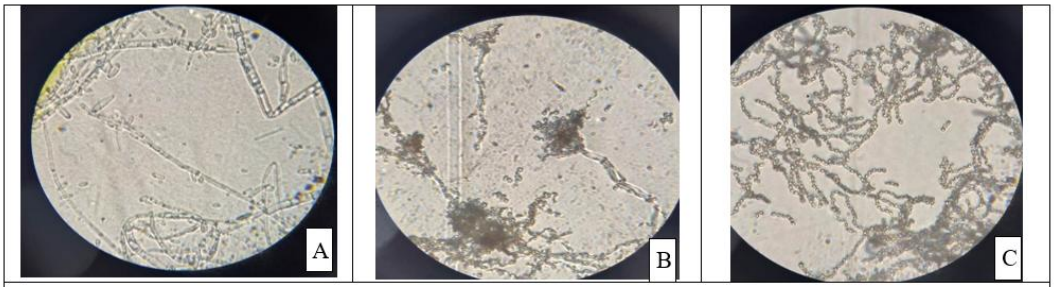

Figure 4. Microscopic morphology of fungal spores isolated from sea buckthorn. (A) *Fusarium* sp.; (B) *Verticillium* sp.; (C) *Monilia* sp.

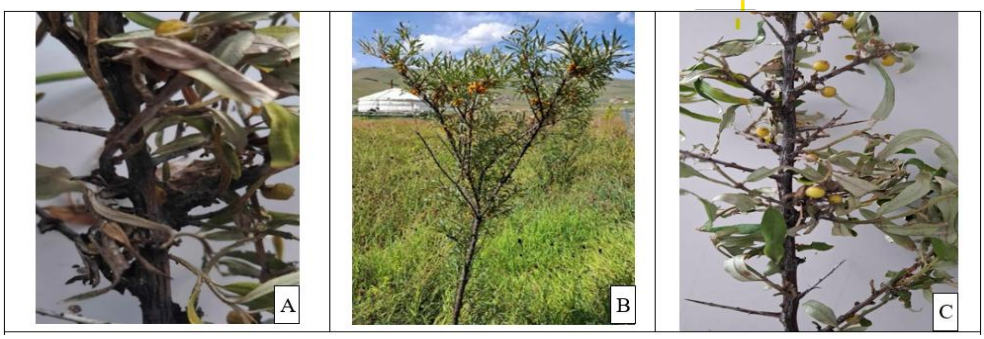

Figure 5. Representative symptoms of fungal diseases observed on sea buckthorn plants. (A) Leaf wilting and curling; (B) Branch dieback and canopy decline; (C) Fruit discoloration and shriveling.

Discussion

Sea buckthorn cultivation has expanded rapidly in Mongolia during the past decade. National production of fruits and berries increased from 578,179 kg in 2010 to 2,305,337 kg in 2023, while sea buckthorn production alone increased from 578,179 kg to 1,964,855 kg during the same period [14]. The expansion of cultivation may have increased opportunities for pathogen establishment and disease spread, particularly in intensive production areas.

In the present study, four fungal diseases were identified in cultivated sea buckthorn plantations: Verticillium wilt (*Verticillium spp*.), Fusarium wilt (*Fusarium spp*.), brown rot (*Monilia spp*.), and brown spot (Alternaria spp.). Among these, Verticillium wilt was the most prevalent disease, accounting for 36.36% of all samples, followed by Fusarium wiltand brown rot (27.27% each). These findings support our hypothesis that Verticillium, Fusarium, and Monilia are among the dominant fungal pathogens affecting cultivated sea buckthorn in Mongolia.

Our results are generally consistent with previous studies conducted in Mongolia. A survey in Selenge Province reported the occurrence of Fusarium wilt (Fusarium sporotrichioides), Verticillium wilt (Verticillium dahliae), and Endomycosis (Monilia altaica) as the major diseases of sea buckthorn plantations [15]. Similarly, Gantuya et al. (2018) identified Verticillium wilt, Fusarium wilt, Endomycosis, leaf spot, and black canker as the principal fungal diseases affecting sea buckthorn across several provinces of Mongolia. Although disease prevalence varied among studies, likely due to differences in sampling location, environmental conditions, cultivation practices, and survey periods, the same major pathogen groups were consistently detected.

The predominance of Verticillium wilt observed in the present study is of particular concern. Species of Verticillium are soil-borne pathogens capable of surviving for extended periods in soil through resistant structures and infecting a wide range of host plants [16]. Sea buckthorn is considered susceptible to Verticillium wilt, which can cause vascular discoloration, wilting, branch dieback, reduced productivity, and eventual plant death [7, 17]. The relatively high prevalence observed in this study suggests that Verticillium wilt remains one of the most important constraints to sustainable sea buckthorn production in Mongolia.

The occurrence of Fusarium wiltand brown rot also highlights the importance of fungal diseases affecting both vegetative and reproductive organs of sea buckthorn. Similar pathogens have been reported in sea buckthorn-growing regions worldwide, including *Fusarium*, *Alternaria*, *Botrytis*, and *Pythium* species [7]. These pathogens reduce fruit quality, plant vigor, and overall productivity, resulting in economic losses for growers. Recent studies have further demonstrated that complex fungal communities are associated with sea buckthorn decline and canker diseases, emphasizing the need for continuous disease monitoring and effective disease management strategies [5].

Overall, the results demonstrate that fungal diseases remain a significant challenge in cultivated sea buckthorn plantations in Mongolia. Continued disease surveillance, accurate pathogen identification, and the development of environmentally sustainable disease management approaches, including biological control methods, are essential for maintaining healthy plantations and supporting the long-term expansion of sea buckthorn production.

Conclusion

This study identified four major fungal diseases affecting cultivated sea buckthorn in the surveyed regions of Mongolia: Verticillium wilt, Fusarium dried-shrink, brown rot, and brown spot. Verticillium wilt was the most prevalent disease, followed by Fusarium dried-shrink and brown rot. These findings provide baseline information for disease monitoring and support the development of sustainable disease management strategies, including biological control approaches.

Author's contribution

Ts.D. and A.S. collected diseased sea buckthorn samples. G.M. assisted in the identification of sea buckthorn diseases and in obtaining pure cultures of the pathogens. N.D. participated in the extraction of DNA from the pathogenic fungi. O.D. carried out field surveys, collected sample materials, and worked on isolating and identifying pure fungal cultures. This research was supervised and guided by my advisor, B.M.

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