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Insect pests and diseases of Lai Chau ginseng (*Panax vietnamensis var. fuscidiscus* K. Komatsu, S. Zhu & S.Q. Cai)

Hien Thuy Phan[1], My Thi Chu[1*], Ha Thi Dang[1], Binh Thi Nguyen[1, 2], Tien Tran Minh[3], Hien Nguyen[4], Stephen Harper[2]

[1]*National Institute of Medicinal Materials, 3B Quang Trung Street, Cua Nam Ward, Hanoi, Vietnam*
[2]*The University of Queensland, Brisbane 4072, Australia*
[3]*Vietnam Academy of Agricultural Sciences, Thanh Tri Ward, Hanoi, Vietnam*
[4]*Vietnam Women's Union, 39 Hang Chuoi Street, Cua Nam Ward, Hanoi, Vietnam*

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Abstract:

***Panax vietnamensis* var. *fuscidiscus*, commonly known as Lai Chau ginseng, is a high-value medicinal plant native to the mountainous regions of northern Vietnam. To develop effective management strategies for Lai Chau ginseng, this research aimed to comprehensively assess the pests and diseases affecting its cultivation. In 2024, a survey was conducted in Sin Ho, Lai Chau province. A total of 48 symptomatic plant samples were collected and evaluated based on morphological characteristics and visible symptoms. Four major symptom groups were identified: insect-induced leaf damage (32%), damping off (29%), leaf spots (20%), and root rot and wilting. Two key insect pests were identified: *Chinavia hilaris* (green stink bug) and *Pseudococcus citri* (mealybug), which caused significant damage to flowers, fruits, and petioles. Additionally, five pathogens were identified, including *Cladosporium paeoniae* (leaf spot), *Puccinia* sp. (rust), and three soil-borne fungi (*Fusarium solani*, *Pythium ultimum*, and *Rhizoctonia solani*), responsible for root rot and damping-off. These findings provide important baseline data for developing Integrated Pest Management (IPM) strategies to support the sustainable cultivation of Lai Chau ginseng.**

Keywords: **damping-off, green stink bug, Lai Chau ginseng, mealybug, root rot, Sin Ho.**

Classification numbers: **3.1, 3.4**

1. Introduction

Lai Chau ginseng (*Panax vietnamensis* var. *fuscidiscus*) is a unique medicinal plant species native to northern Vietnam. It was first confirmed by K.L. Phan, et al. (2013) [1] and is closely related to *Panax vietnamensis* (Ngoc Linh ginseng). Lai Chau ginseng contains a wide range of saponins, including ginsenosides, which enhance physical strength, as well as high concentrations of majonoside, known for their antidepressant, antioxidant, and hepatoprotective effects [2, 3].

In recent years, due to its high economic and medicinal value, Lai Chau ginseng has become a focal point for local development, particularly in Sin Ho, Lai Chau, Vietnam.

Lai Chau ginseng shares morphological similarities with Ngoc Linh ginseng, a species known to be highly susceptible to various pests, which is a common challenge across the *Panax* genus. Numerous reports detail pest damage within the *Panax* genus. For example, surveys conducted on Ngoc Linh ginseng cultivation sites in Vietnam from 2013 to 2015 identified 14 harmful species, including key arthropod pests such as leaf rollers, bush-crickets, grasshoppers, and field crickets, as well as diseases like damping off (*Rhizoctonia solani*) and yellow rust (*Puccinia* sp.) [4]. Similarly, American ginseng (*Panax quinquefolius* L.) is widely affected by soil-borne fungal diseases such as *Phytophthora cactorum* [5] and *Cylindrocarpon destructans* [6]. Comprehensive Canadian surveys further documented various root rot fungi, including *Pythium ultimum*, *Fusarium solani*, *Fusarium oxysporum*, *Fusarium avenaceum* [*Gibberella avenacea*], *F. equiseti*, *Rhizoctonia solani* AG 4, and *Cylindrocarpon destructans* [*Nectria radicicola*] in young American ginseng. The survey also recorded various foliar pathogens, such as *Phytophthora cactorum*, *Alternaria panax*, *Alternaria alternata*, and grey mould (*Botrytis cinerea*) [7, 8]. For Korean ginseng

*Corresponding author: Email: chumybvb@gmail.com

(*Panax ginseng*), serious damage has been attributed to nematodes [9] and bacterial diseases caused by *Erwinia*, *Pseudomonas*, and *Agrobacterium* [10].

Despite its importance in cultivation, published data on arthropod pests and diseases affecting Lai Chau ginseng remain limited. As the cultivation of Lai Chau ginseng continues to expand, often in net-houses managed by both local communities and commercial entities, with some companies overseeing up to two hectares, there is an urgent need for comprehensive research into the arthropod pests and diseases to support Integrated Pest Management (IPM).

This study presents the first documentation detailing the arthropod pests and diseases affecting Lai Chau ginseng grown in Sin Ho, Lai Chau province, Vietnam. These findings provide essential baseline data for establishing IPM strategies for this valuable medicinal plant.

2. Materials and methods

2.1. Sample sites and collection

Plant samples exhibiting symptoms of insect pests and diseases were collected from four farms in the Ta Phin, Ta Ngao, and Sa De Phin communes in Sin Ho, Lai Chau province, Vietnam (Fig. 1), during the growing season. The first sample collection took place in May 2024, followed by a second collection in October 2024. The collection was strictly based on a visual assessment of symptoms that were presumed to be the result of pathogen infection, such as wilting plants, root lesions, and rusted spots on leaves. From each symptomatic plant, 1-2 representative leaves or segments of affected plant parts (roots or entire plants) were collected and immediately placed into labelled plastic bags to prevent cross-contamination and desiccation. The samples were then kept in a cooler with ice packs and transported to the laboratory for further analysis.

2.2. Laboratory assessment

2.2.1. Insect pest identification

Insect pest species were identified based on their morphological features and classified using the identification guide by D.J. Borror, et al. (1989) [11].

2.2.2. Pathogen identification

The collected samples were morphologically described and assessed according to H.L. Barnett, et al. (1998) [12] and S.B. Mathur, et al. (2003) [13]. The identification of pathogens was carried out according to Koch's postulates (1876), with the following four steps:

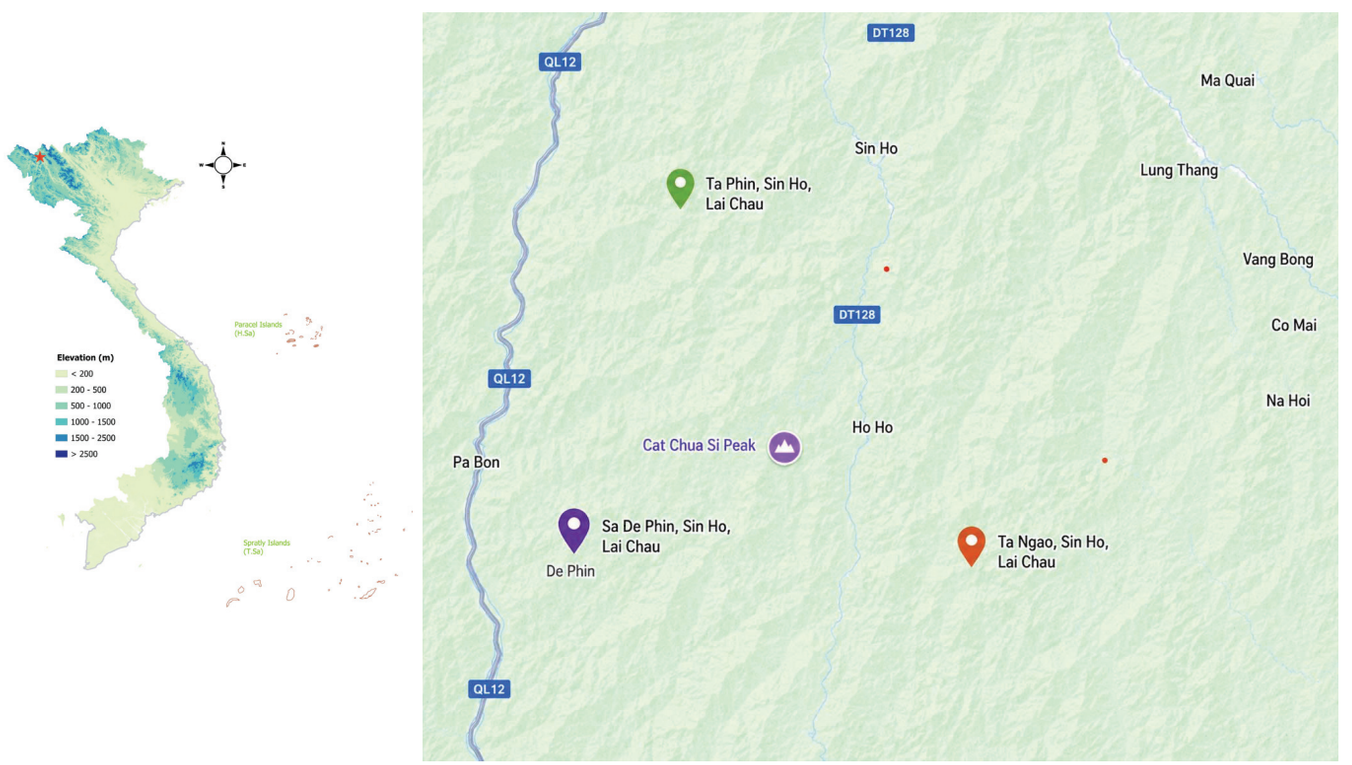

Fig. 1. The sampling sites (Ta Ngao, Sa De Phin and Ta Phin) across Sin Ho, Lai Chau province, Vietnam where the insect pest and disease samples were collected in 2024. Source: https://maisonoffice.vn.

Step 1: Symptom description and identification

This step involved a detailed visual assessment of the plants for disease symptoms. We meticulously described the morphology and location of the symptoms. This included characterising wilting by loss of turgor; spots by their distinct colour, size, and shape; and rhizome rots by changes in tissue integrity and discoloration. We also noted the presence, colour, texture, and arrangement of mycelial growth or fruiting bodies, as well as any lesions and associated exudates or odours. This detailed visual profile guided subsequent sample collection for laboratory confirmation.

Step 2: Pathogen isolation and morphological assessment

Symptomatic plant tissues were surface-sterilised, and small sections were plated onto specific culture media (e.g., WA, mPDA, CMA) and subsequently incubated. Pure microbial isolates were obtained through subculturing. Each pure isolate underwent a microscopic morphological assessment, detailing colony characteristics (colour, texture, growth pattern), hyphal features (septation, branching), and reproductive structures (spores, conidia, sporangia) based on their size, shape, colour, and arrangement. These observations provided preliminary pathogen identification.

Step 3: Pathogenicity testing

Pathogenicity tests were conducted by inoculating healthy ginseng plants with isolated pathogens. The inoculated plants were maintained under controlled environmental conditions and observed daily. Symptom development on the inoculated plants was recorded and compared to the original field observations. Re-isolation of the pathogen from infected plants confirmed pathogenicity (Koch's postulates).

Step 4: Pathogen re-isolation and confirmation

The final step in confirming pathogenicity involved re-isolating the pathogen from the newly infected plants that developed disease symptoms following inoculation. This re-isolated pathogen was then meticulously compared to the original isolate obtained from the field. Morphological characteristics (as described in Step 2) were used to confirm that the re-isolated pathogen was indeed the same as the initial isolate. This crucial step fully satisfies Koch's postulates, thereby confirming the causal agent of the observed disease.

The method for isolating and culturing the fungal pathogens in the laboratory was carried out according to L.W. Burgess, et al. (2008) [14]. The specimen was thoroughly washed to remove soil particles and then placed in a Petri dish containing sterile absorbent paper. The development of pathogenic microorganisms was observed after 1-2 days. To isolate the pathogen, the sample was washed, and a representative section was selected and cut into 1x1 cm pieces at the boundary between diseased and healthy tissue. The sample was surface sterilised with 70% alcohol for 15-20 seconds and then rinsed with sterile distilled water. The section was dried with sterile absorbent paper, and a sterilised scalpel was used to cut the infected tissue into small pieces measuring 5x5 mm. The sections were then placed on isolation media, including agar-distilled water (WA) (with antibiotics added) and potato-sugar-modified agar medium (mPDA). When the fungal colonies had grown to a diameter of 1-2 cm, the isolates were transferred to WA medium for the purpose of purifying the fungus. The growth tip of the mycelium was transferred from the intermediate medium (WA) to potato-sugar-agar (PDA), potato-carrot agar (PCA), or CLA.

Pathogens were identified based on the works of H.L. Barnett, et al. (1998) [12], S.B. Mathur, et al. (2003) [13], the Plant Protection Institute (1997) [15], and V.T.T. Dang, et al. (1997) [16].

3. Results and discussion

3.1. Classification of collected samples

After collection, samples were systematically classified based on disease symptoms and signs of insect pests. The initial classification of insect pest and disease samples from Lai Chau ginseng was based on observed symptoms. These were then grouped into four main symptom categories (Fig. 2), which included insect-induced leaf damage, leaf spots, damping off, and root rot. Among these, insect-induced damage was the most frequently observed, accounting for 32% of the samples. Damping off followed at 29%, with leaf spots comprising 20%. Root rot represented the smallest proportion of samples at 19%.

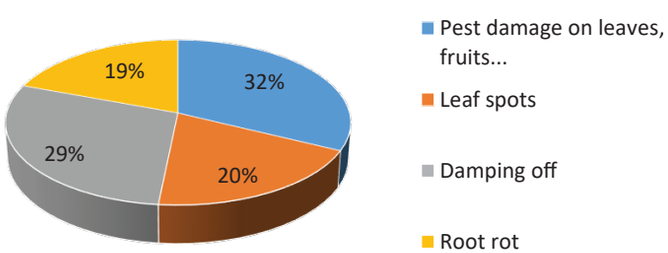

Fig. 2. Proportion of main symptom groups identified in Lai Chau ginseng samples collected in Sin Ho, Lai Chau, Vietnam in 2024.

3.2. Pest and disease findings on Lai Chau ginseng

The examination and isolation of insect pest and disease samples on Lai Chau ginseng identified seven common harmful species, as detailed in Table 1.

Table 1. Insect pests and pathogens associated with Lai Chau ginseng plants in Sin Ho, Lai Chau, Vietnam, 2024.

Category	Common name of pest/ disease	Symptoms	Scientific name	Number of affected samples	Damaged parts
Insect pests	Green stink bug	Damage on leaves and fruits, leading to yellow dry fruits and leaf spots	*Chinavia hilaris*	8	Leaves, young fruits
	Mealybug	Damage on leaves, fruits	*Pseudococcus citri*	6	Leaves, young fruits
Diseases	Rust	Leaf spots and yellow rust on the underside of the leaves	*Puccinia sp.*	6	Leaves, young shoots, fruits
	Leaf spot	Leaf spots	*Cladosporium paeoniae*	6	Leaves
	Damping off	Damping off, dieback	*Rhizoctonia solani*	9	Stems, roots
	Pythium root	Root rot	*Pythium ultimum*	8	Roots
	Fusarium root	Root rot	*Fusarium solani*	5	Roots, rhizomes

Among the identified pest species, the green stink bug (*Chinavia hilaris*) and the mealybug (*Pseudococcus citri*) were found to primarily damage the leaves, fruits, and flowers.

Furthermore, five distinct diseases were identified affecting Lai Chau ginseng. These included two foliar diseases: rust (*Puccinia* sp.) and leaf spots (*C. paeoniae*). In addition, three diseases causing plant mortality and root rot were prevalent in the collected samples from Sin Ho: damping off (*R. solani*) and root rot (*F. solani* and *P. ultimum*).

3.3. Characteristics and development of insect pests affecting Lai Chau ginseng

3.3.1. Green stink bug (Chinavia hilaris)

Damage characteristics: Damage to Lai Chau ginseng is primarily caused by adults, leading to misshapen plant tissue characterised by rough, white spongy areas and corky margins. Occasionally, egg-laying on ginseng fruits results in nymphs depleting sap from developing fruits (Fig. 3A), further hindering their growth.

Morphological characteristics: The green stink bug is identifiable by its typically bright green colour, often featuring narrow yellow, orange, or reddish edges. It is a large, shield-shaped bug with an elongated, oval body and usually measuring between 13 and 18 mm in length (Fig. 3B).

Occurrence and development: These pests exhibit high population density and often cause significant damage to Lai Chau ginseng plants within greenhouse environments, particularly during the flowering and young fruit development stages.

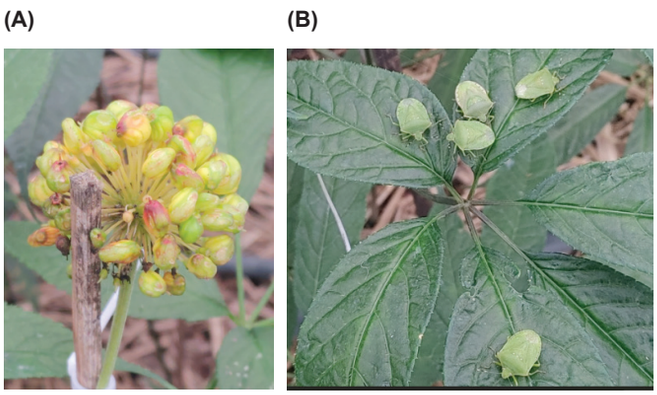

Fig. 3. Green stink bug (*Chinavia hilaris*) on Lai Chau ginseng, illustrating characteristic morphological features and the resulting damage to (A) fruits and (B) leaves.

3.3.2. Mealybug (Pseudococcus citri)

Damage characteristics: Females mealybugs, the primary damaging stage, feed by sucking sap from plant tissues. They typically congregate in stem axils, other crevices, and occasionally at the base of ginseng fruits. They secure themselves to the plant and secrete a protective powdery wax layer as they feed.

Morphological characteristics: Male mealybugs are short-lived, non-feeding and function solely to fertilise females. Male mealybugs are winged and resembling small, fluffy gnats as they fly to locate mates (Fig. 4).

Occurrence and development: These pests frequently cause substantial damage in greenhouse environments, with infestations peaking during the flowering and young fruit development stages of Lai Chau ginseng.

Fig. 4. Morphological characteristics of mealybug (*Pseudococcus citri)* and damage symptoms on different parts of Lai Chau ginseng: (A) fruits; (B) stem.

3.4. Symptoms, pathogenic agents of diseases affecting Lai Chau ginseng

3.4.1. Leaf spot (Cladosporium paeoniae)

Damage symptoms: Leaf spot disease can lead to both local and systemic effects on Lai Chau ginseng. In the initial stage, amorphous yellow spots appear on the leaves, with lesions typically measuring about 1-2 mm in diameter. These lesions are often yellow in the centre, appearing white to light yellow on the upper leaf surface, and dark yellow on the lower leaf surface (Fig. 5). This disease can severely damage both old and young leaves, directly impairing the photosynthetic process and leading to premature leaf loss.

The pathogen: The causal pathogen is a fungus characterised by aseptate hyphae and unicellular, rice-shaped conidia that are typically arranged in chains.

Conditions for disease development: The disease exhibits strong development from June to August, correlating with rainy weather and high humidity. Conversely, its progression gradually declines during dry and sunny periods with low humidity.

3.4.2. Rust (Puccinia sp.)

Damage symptoms: Initially, rust infection on Lai Chau ginseng manifests as chlorotic (yellow) spots exclusively on the upper leaf surface. In advanced stages, lesions expand to the lower leaf surface, fruits and stems. Infected plants typically exhibit weakness and stunted growth, and rapidly collapse if environmental conditions favour further disease development. A characteristic symptom is the appearance of cracked leaves that contain a mass of yellow powder internally. This powder is initially light yellow and gradually darkens with age (Fig. 6).

Conditions for disease development: The disease typically emerges in May, with severe damage observed during September and October. Rust primarily affects mature ginseng plants, particularly those aged three years or older. Its occurrence coincides with the onset of the rainy season, significantly impacting plant growth and development. Notably, plants cultivated under a forest canopy are often more severely infected with rust compared to those grown in a greenhouse environment.

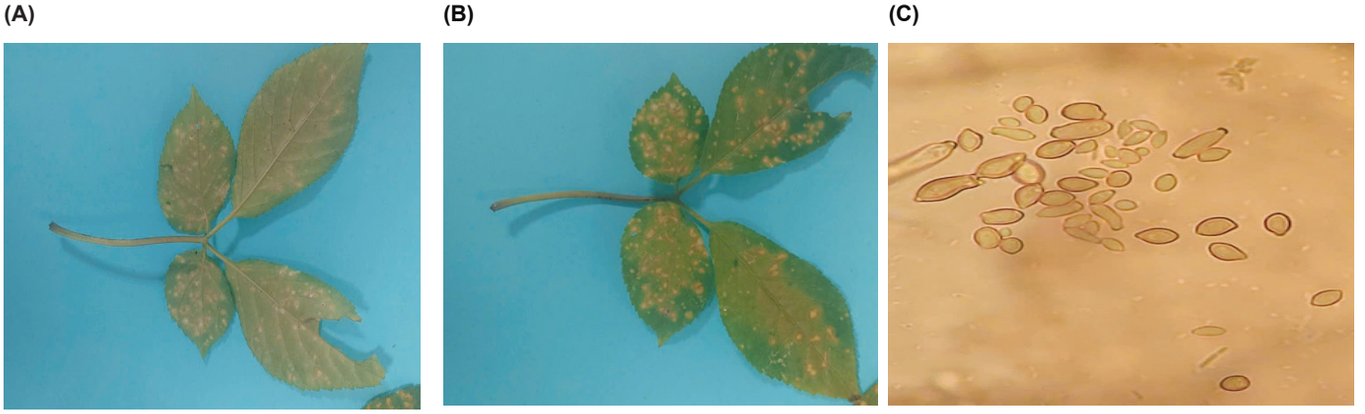

Fig. 5. Disease symptoms and morphological characteristics of *C. paeoniae*. on Lai Chau ginseng: (A) lower leaf surface, (B) upper leaf surface, under field conditions, and (C) conidia of isolated *C. paeoniae*.

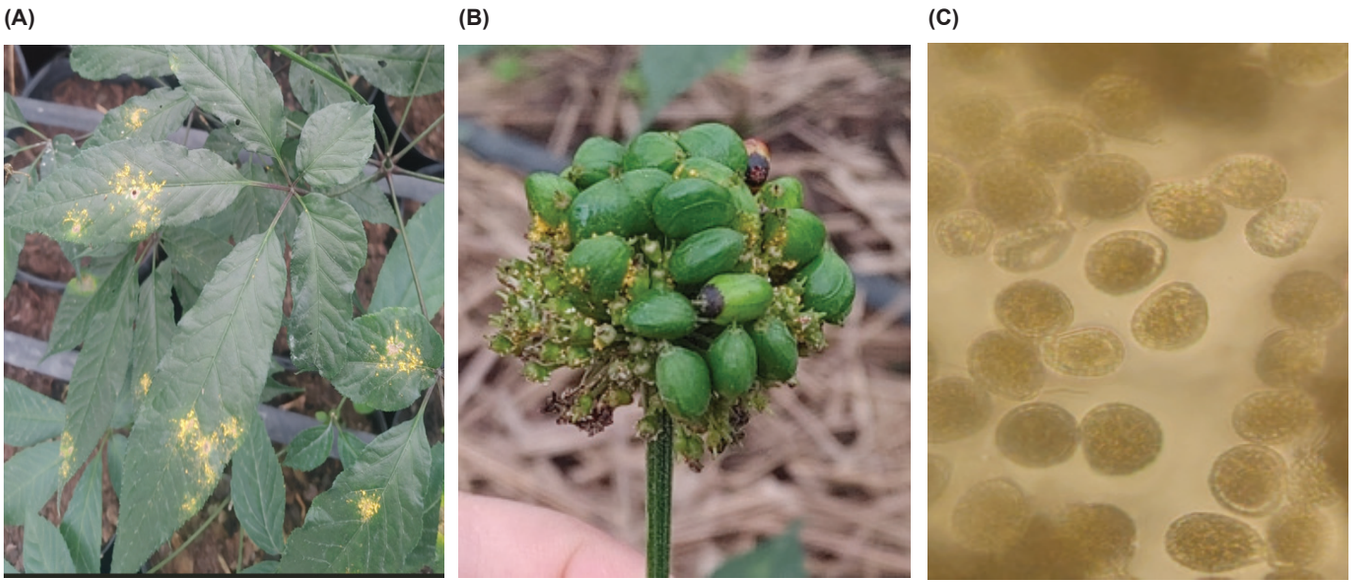

Fig. 6. Typical rust symptoms on Lai Chau ginseng leaves (A) and fruits (B) and morphological characteristics (C) of *Puccinia* sp. in Lai Chau ginseng.

3.4.3. Seedling damping-off (Rhizoctonia solani)

Damage symptoms: The disease typically manifests at the base of the stem, close to the ground (Figs. 7A and 7B). A characteristic symptom is the constriction of the plant's base, which can lead to lodging or toppling over. When affected plants are uprooted, the roots often break off, and the fractured area exhibits signs of rot. Despite the decay at the base and in the roots, the leaves may remain green, even as the overall plant appears withered.

The pathogen: The causal agent is the filamentous fungus *Rhizoctonia solani*. This pathogenic fungus is characterised by multicellular hyphae with numerous branches (Fig. 7C). A distinctive feature is that the branching areas of the mycelium are often slightly constricted, with septa located close to these constrictions, and branching typically occurs almost perpendicularly. Under the conditions of high air humidity, the fungus forms brown to dark brown sclerotia with irregular shapes.

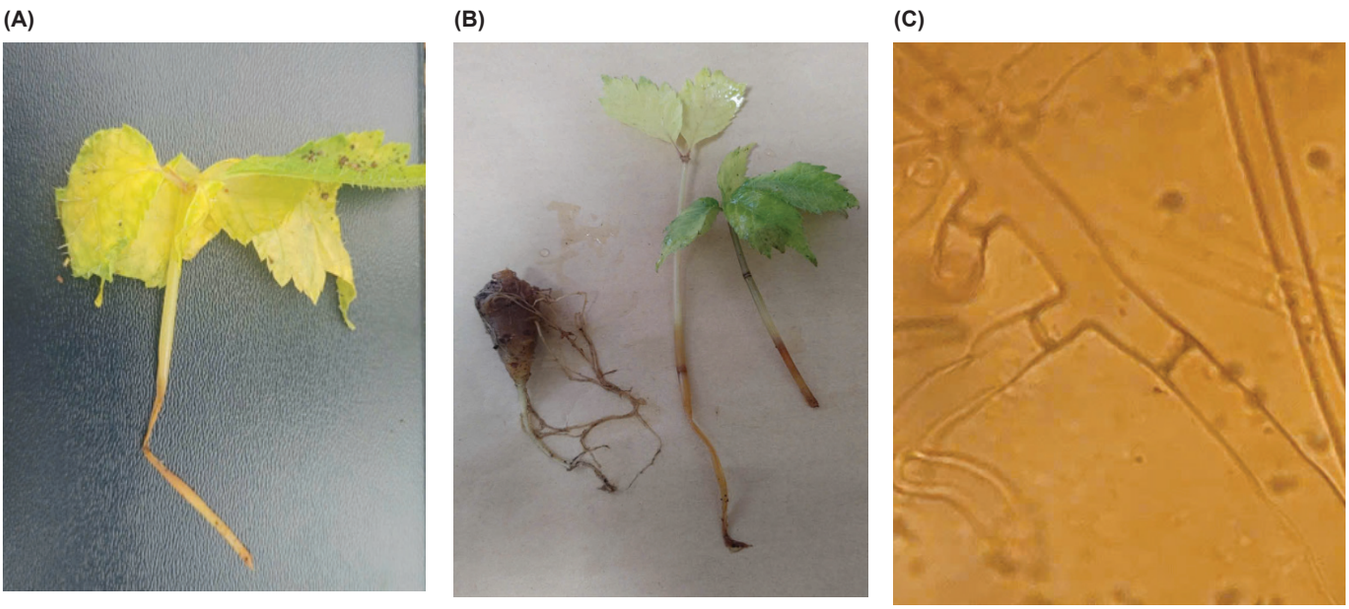

Fig. 7. Damping-off on Lai Chau ginseng seedlings caused by *Rhizoctonia solani*. (A, B) Symptoms on the stem, **(C)** The characteristic hyphal morphology of *R. solani*.

Conditions for disease development: The disease frequently emerges and thrives in humid conditions with air temperature ranging approximately from 22 - 28°C. It mainly affects Lai Chau ginseng in the nursery stage.

3.4.4. Pythium root rot disease (Pythium ultimum)

Damage symptoms: When Lai Chau ginseng plants are infected with root rot, they exhibit stunted growth and wilting, even while the leaves remain green (Fig. 8A). A distinctive characteristic is that the plant wilts as its young roots begin to rot and the smaller roots often break easily upon examination (Fig. 8B).

The pathogen: The causal agents are rapidly growing mycelium. These pathogenic fungi produce abundant white, cottony mycelia when cultured on PDA medium. *P. ultimum* forms characteristic spores effectively in PCA and rice leaf water media. *Pythium* sporangia, which are key reproductive structures, are observed as round (spherical) or filamentous (swollen hyphae-like) bodies, forming either at the tips or between the hyphae (Fig. 8C).

Conditions for disease development: Pythium root rot on Lai Chau ginseng thrives particularly during the seedling stage of the plant. High temperatures combined with high air humidity are conducive to its emergence and rapid development.

3.4.5. Root rot disease (Fusarium solani)

Damage symptoms: When Lai Chau ginseng plants are infected with root rot, they exhibit stunted growth and wilting. A notable characteristic is that the plant wilts even while its leaves remain green (Fig. 9A). The rhizome often undergoes a dry rot, initially retaining its shape, but the internal tissue gradually rots and decomposes, leaving only the tuber peel in the soil (Fig. 9B).

The pathogen: The causal agent is the fungus Fusarium solani. This pathogenic fungus produces fast-growing mycelium, often appearing as abundant white, cottony growth on PDA medium (Fig. 9C). Fusarium solani is characterised by the production of large, crescent-shaped macroconidia and smaller microconidia attached to long-stalked monophialides (Fig. 9D).

Conditions for disease development: Fusarium root rot on Lai Chau ginseng thrives particularly during the rhizome formation stage, typically in plants aged two years or older. The emergence and spread of this disease are significantly favoured by high temperature and high humidity.

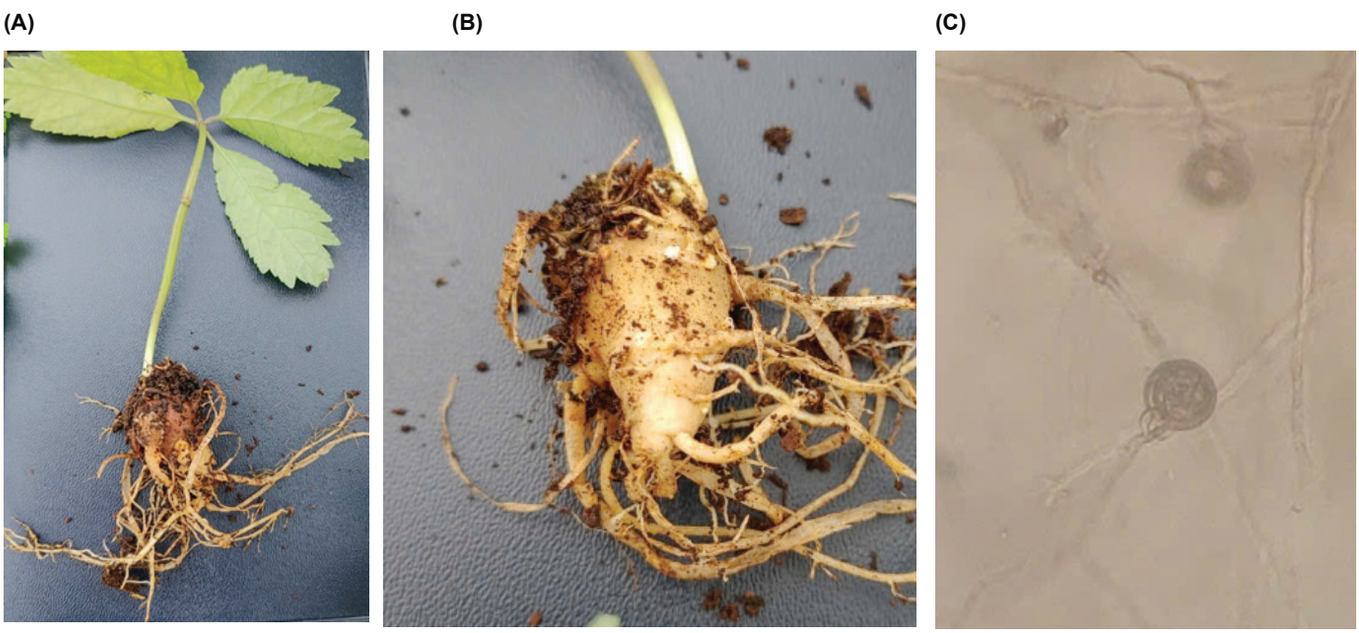

Fig. 8. Root rot disease caused by *Pythium ultimum* on Lai Chau ginseng. (A, B) Typical root rot symptoms, **(C)** The pathogenic agent (*Pythium sporangia*).

Fig. 9. Root rot disease caused by *Fusarium solani* on Lai Chau ginseng. (A, B) Disease symptoms on roots; **(C, D)** *F. solani* mycelium on PDA and characteristic microconidia formed in false heads on CLA.

4. Conclusions

This study identified a total of seven species of arthropod pests and fungal pathogens damaging Lai Chau ginseng plants cultivated in the Ta Ngao, Ta Phin, and Sa De Phin communes of Sin Ho, Lai Chau. Regarding insect pests, the green stink bug (*Chinavia hilaris*) and the mealybug (*Pseudococcus citri*), caused significant damage, primarily affecting the flowers, fruits, and petioles of the plant. Among the diseases, five prevalent fungal pathogens were identified, encompassing foliar diseases such as leaf spot (*Cladosporium paeoniae*) and rust (*Puccinia* sp.), as well as three diseases causing root rot and seedling damping-off due to soil-borne fungi (*Fusarium solani*, *Pythium ultimum*, and *Rhizoctonia solani*).

The characterisation of these pests and pathogens provides a scientific basis for developing targeted Integrated Pest Management (IPM) strategies, which are essential for future research and the sustainable cultivation of this high-value medicinal plant.

CRediT author statement

Hien Thuy Phan: Investigation, Sample collection, Laboratory analysis, Methodology, Reviewing and Editing; My Thi Chu: Investigation, Sample collection, Laboratory analysis, Methodology, Data analysis, Original draft preparation, Editing; Ha Thi Dang: Laboratory analysis, Methodology, Data analysis; Binh Thi Nguyen: Investigation, Sample collection, Reviewing and Editing; Tien Tran Minh: Investigation, Sample collection; Hien

Nguyen: Investigation, Sample collection; Stephen Harper: Investigation, Sample collection; Reviewing and Editing.

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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