Plant Diseases and Pests 2024, 15 (4): 13 – 16 DOI: 10.19579/j.cnki.plant-d.p.2024.04.003

Damage and Control Suggestions for the Emerging Disease Coffee Root Rot

Xingfei FU, Guiping LI, Faguang HU*

Institute of Tropical and Subtropical Cash Crops, Yunnan Academy of Agricultural Sciences, Baoshan 678000, China

Abstract [**Objectives**] The paper was to elucidate the symptoms, morphological characteristics, etiological factors, and current extent of damage associated with coffee root rot disease. [**Methods**] The symptoms, morphological characteristics, and etiological factors associated with coffee root rot disease were systematically observed, described, and analyzed. The assessment of damage was carried out using a specialized investigative methodology. [**Results**] The application of bottom fertilizer containing *Fusarium incarnatum* facilitated the pathogen's entry through root wounds during transplantation, resulting in the development of water-soaked depression lesions in the affected areas. This infection significantly reduced the number of lateral roots in coffee plants, leading to symptoms such as wilting, withering, and ultimately, the death of the aboveground foliage. *F. incarnatum* exhibited three distinct types of spore morphology: macroconidia, which were sickle-shaped; mesoconidia, which were spindle-shaped; and microconidia, which were oval-shaped. The incidence rate of the disease in the affected region reached 100%, with a disease index exceeding 91, indicating severe damage. [**Conclusions**] This study serves as a valuable reference for the prevention and management of the emerging disease known as coffee root rot.

Key words *Coffea arabica*; Root rot; *Fusarium incarnatum*; Prevention and control; New diseases

1 Introduction

Coffee represents one of the most distinctive and beneficial industries in Yunnan Province. As of 2022, the area dedicated to coffee cultivation in Yunnan Province spanned 84 900 hm^2, which constitutes 98.38% of the total coffee cultivation area in China. The province produced 115 100 t of coffee, accounting for 98.70% of the national coffee production. The agricultural output value of this sector reached 3.448 billion yuan, representing 98.40% of the national agricultural output value[1]. In recent years, the impact of climate change, the renewal of coffee varieties, the optimization of production areas, alterations in planting patterns, the frequent transfer of seedlings between production regions, and ongoing innovations in cultivation technology have contributed to a rise in new diseases and pests. Notably, 57 new species of pests detrimental to *Coffea arabica* have been documented in China alone[2]. In 2022, a suspected strain of coffee root rot was identified for the first time at the coffee seedling base of the Institute of Tropical and Subtropical Cash Crops, Yunnan Academy of Agricultural Sciences. Morphological and molecular biological analyses confirmed that the pathogen responsible for the disease was *Fusarium incarnatum*, marking it as a newly recorded disease affecting *C. arabica* in China[3].

F. incarnatum is an important pathogen causing fruit rot, stem rot and root rot, such as cantaloupe *Fusarium* fruit rot, sweet melon fruit rot and corn stem rot, *etc.*[4-6]. Previous research on *F. incarnatum* primarily concentrates on three key areas: morphology, biological characteristics, and methods of prevention and control. Wu Lifang *et al.*[4] demonstrated that the large conidia of *F. incarnatum* exhibited a sickle shape, measuring between 25.4 – 35.5 μm in length and 3.3 – 5.4 μm in width. The optimal growth temperature for this species was identified as 30 ℃, while the optimal pH range was found to be between 7 and 9. Wang Yan *et al.*[5] determined that the optimal temperature range for the mycelial growth of this pathogen was between 20 and 35 ℃. Maximum sporulation occurred at temperatures ranging from 20 to 25 ℃, while the most rapid mycelial growth was observed at a pH of 8. Furthermore, the lethal temperature for mycelium was 61 ℃ when exposed for 10 min, and for conidia, it was 56 ℃ under the same exposure duration. In addition, *F. incarnatum* exhibited a broad host spectrum, with root associations observed in *Zea mays*[6], *Orychophragmus violaceus*[7], and *Lycium chinense*[8].

Coffee root rot is an emerging disease attributed to the pathogen *F. incarnatum*. Currently, there is a lack of comprehensive reports detailing the field symptoms, morphological characteristics of the pathogen, the underlying pathogenic mechanisms, and the extent of damage caused by this disease. This absence of information significantly hinders effective identification and management strategies for controlling the disease. This paper presents a detailed description of the field symptoms associated with coffee root rot, as well as the morphological characteristics of the pathogenic bacteria responsible for the disease. The aim is to provide a reference for the identification and understanding of emerging coffee root rot diseases. The etiology of the disease was investigated through field studies, analysis of production records, and consultations with managers from various planting sites. Additionally, the extent of damage caused by coffee root rot in affected areas was assessed using specialized investigative methods. In conclusion, scientifically grounded and effective recommendations for the pre-

Received: April 15, 2024 Accepted: July 20, 2024

Supported by Innovation Guidance and Technology-based Enterprise Cultivation Program of Yunnan Science and Technology Project (202304BP090027); Hu Faguang Expert Grassroots Scientific Research Workstation of Pu'er Aini Manor Coffee Co., Ltd.

* Corresponding author. E-mail: hfg2632@126.com

vention and control of the novel disease, coffee root rot, have been developed to serve as a technical reference for its management.

2 Materials and methods

2.1 Survey scope The initial identification of coffee root rot occurred in 2022 at the Institute of Tropical and Subtropical Cash Crops, Yunnan Academy of Agricultural Sciences. An examination of the seedling transport records revealed that the shipment in question originated from five distinct planting areas associated with the Institute of Tropical and Subtropical Cash Crops, as well as from Baoshan Lushan Yunshu Agricultural Development Co., Ltd., Baoshan Qingjia Agricultural Co., Ltd., Nujiang Lishu Coffee Co., Ltd., and the Baoshan Longyang District Cash Crop Technology Extension Center. Consequently, this survey was exclusively focused on the five aforementioned growing areas.

2.2 Survey methods

2.2.1 Observation of symptoms. Canon EOS 60D digital camera was utilized to document the symptoms of coffee root rot at various stages of damage, including both the plant roots and aerial parts.

2.2.2 Morphological observation of pathogenic bacteria. The pathogens were inoculated onto potato dextrose agar (PDA) medium plates, and the characteristics of the colony cultures were observed after a period of 7 d. Subsequently, the morphology and size of the conidia were examined using an optical microscope following spore production.

2.2.3 Investigation of pathogenesis. Concurrently, the etiological factors contributing to coffee root rot disease were comprehensively examined and analyzed through field investigations, the review of production records, and consultations with managers from each cultivation site.

2.2.4 Damage investigation. In 2022, an investigation was conducted to assess the extent of coffee root rot damage across five coffee cultivation sites, namely the Institute of Tropical and Subtropical Cash Crops of the Yunnan Academy of Agricultural Sciences, Baoshan Lushan Yunshu Agricultural Development Co., Ltd., Baoshan Qingjia Agricultural Co., Ltd., Nujiang Lishu Coffee Co., Ltd., and the Baoshan Longyang District Cash Crop Technology Extension Center. This assessment utilized a specialized investigative methodology. A total of 30 coffee plants, sourced from the Institute of Tropical and Subtropical Cash Crops at the Yunnan Academy of Agricultural Sciences, were randomly selected from each investigation site. These plants were categorized into five grades based on the extent of root lesions and their overall growth status. The quantity of plants within each damage grade was systematically recorded. The criteria for damage grading were established as follows: grade 0 indicates the absence of lesions, accompanied by normal plant growth; grade I denotes the presence of a single lesion, with normal plant growth; grade II is characterized by the observation of 2–4 disease spots, along with wilting of the plant leaves; grade III involves the presence of 5–10 disease spots, resulting in significant wilting of the plant leaves; grade IV is defined by the observation of more than 10 disease spots, which exhibit signs of withering and death.

2.3 Data analysis Excel 2020 was utilized to analyze the survey data pertaining to the damage of coffee root rot. The incidence and disease index were computed in accordance with formulae (1) and (2).

$$\text{Incidence} = (\text{Number of diseased plants} / \text{Total number of surveyed plants}) \times 100\% \quad (1)$$

$$\text{Disease index} = \sum(\text{Number of plants at each grade} \times \text{Representative value of the grade}) / (\text{Total number of surveyed plants} \times \text{Representative value of the highest grade}) \times 100\% \quad (2)$$

3 Results and analysis

3.1 Disease symptoms At the onset of the disease, water-soaked, concave lesions were observed on the roots. As the lesions progressed and their number increased, there was a significant reduction in the quantity of lateral roots. Additionally, prominent brown plaques, accompanied by white mycelial growth, were evident at the affected sites. In the advanced stages of the disease, a prominent white mycelium layer became visible, enveloping the affected area and resulting in a noticeable depression. The coloration transitioned from brown to dark brown, accompanied by the manifestation of decay symptoms (Fig. 1A). The aerial portion of the plant exhibited normal growth during the initial stages of the disease, and no significant symptoms were observed. However, as the disease progressed, the plants began to display signs of water deficiency, characterized by wilting leaves that subsequently withered and gradually fell off. Ultimately, the plant succumbed to the disease (Fig. 1B–1C).

3.2 Morphology of pathogen After a culture period of 7 d, the colony exhibited a round morphology with a diameter of 72 mm, accompanied by the production of numerous villous aerial hyphae. Initially, the colony appeared white, but it gradually transitioned to an orange-yellow hue. The back side of the medium displayed a beige coloration (Fig. 2). There were three distinct types of conidia associated with *F. incarnatum* (Fig. 3). The macroconidium was characterized by a sickle shape, measuring from 21.12 to 33.39 μm in length and 3.64 to 6.32 μm in width. It tapered at both ends and exhibited 3–5 septa. The mesoconidium was fusiform, also possessing 3 to 5 septa, with dimensions ranging from 8.36 to 13.25 μm in length and 2.25 to 4.89 μm in width. The microconidium was oval in shape, lacked septation, and measured from 4.25 to 9.98 μm in length and 1.56 to 3.13 μm in width. Conidiophores were produced on the aerial mycelium, with the macroconidia being prominently visible at the apex.

3.3 Pathogenesis During the seedling stage, organic fertilizer containing *F. incarnatum* was incorporated into the soil to serve as the seedling substrate, thereby ensuring the presence of *F. incarnatum* within the seedling container. At the seedling stage, effective management practices, along with sufficient water and fertilizer, contribute to vigorous plant growth, with no observable signs of disease. During the planting process, the long-distance transportation of seedlings and the planting of damaged roots resulted in

NOTE A. Root rot; B. Wilting plants; C. Wilting leaves.

Fig. 1 Damage symptoms of coffee root rot

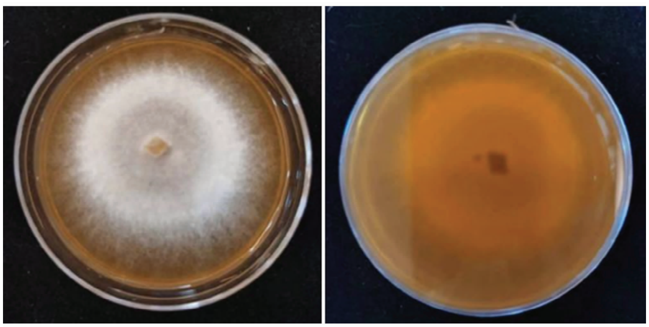

Fig. 2 *Fusarium incarnatum* colony on PDA medium (front and back)

wounds on the roots of coffee plants. Following the planting process, the plants were adversely affected by root pests, including grubs and crickets. This damage resulted in the introduction of pathogens through the wounds inflicted on the roots. The lack of effective bactericidal measures allowed for pathogen invasion through the root wounds. Within the root tissue, conidia of *F. incarnatum* proliferated extensively, obstructing the vascular conduits. This obstruction led to root rot, which impaired the supply of water and nutrients to the plant, causing leaf wilting and an increase in leaf litter. Ultimately, these factors contributed to the death of the plants.

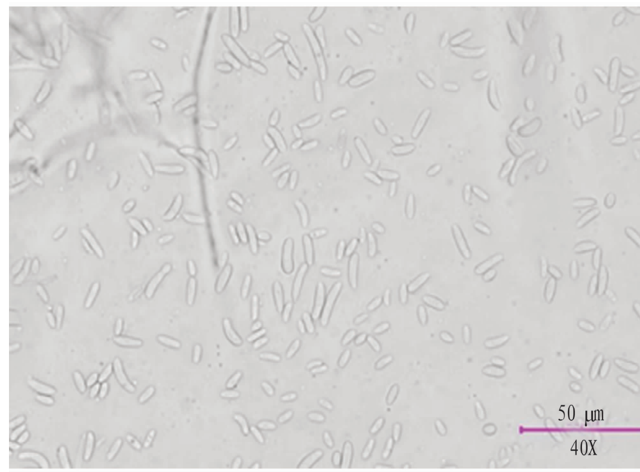

Fig. 3 Conidia of *Fusarium incarnatum*

3.4 Damage status In 2022, an investigation into coffee root rot across five distinct trial or preservation areas revealed that the incidence of coffee root rot in plants sourced from the nursery of the Institute of Tropical and Subtropical Cash Crops at the Yunnan Academy of Agricultural Sciences was 100%. The disease index exceeded 90, and the prevalence of root rot led to the mortality of over 90% of the coffee plants (Table 1).

Table 1 Damage status of coffee root rot in 2022

Survey site	Total number of survey plants	Damage level					Incidence %	Disease index
		0	I	II	III	IV		
Institute of Tropical and Subtropical Cash Crops, Yunnan Academy of Agricultural Sciences	30	0	1	1	1	27	100	95.00
Baoshan Lushan Yunshu Agricultural Development Co., Ltd.	30	0	1	2	3	24	100	91.67
Baoshan Qingjia Agricultural Co., Ltd.	30	0	1	0	1	28	100	96.67
Nujiang Lishu Coffee Co., Ltd.	30	0	0	0	0	30	100	100.00
Baoshan Longyang District Cash Crop Technology Extension Center	30	0	0	0	0	30	100	100.00

4 Discussion

Fusarium Link, recognized as a significant plant pathogen, can induce a range of symptoms in the host, including root rot, stem rot, fruit rot, and leaf spot, following infection. This pathogen poses a substantial threat to plant health and can result in severe damage[9]. Among the identified pathogens, *F. incarnatum* is the primary agent responsible for causing *Fusarium* fruit rot in cantaloupes[4], fruit rot in sweet melons[5], stem rot in corn[6, 10], dry rot in konjac[11], and canker in walnuts[12]. Coffee root rot, caused by *F. incarnatum*, was first reported as a disease in 2022. The detrimental symptoms of this disease can be categorized into two primary types: above-ground and below-ground manifestations. Early detection of the initial infection is challenging, which may result in the oversight of the optimal period for prevention and control measures. The primary manifestations of the disease include water-soaked lesions in the root system, while the above-ground portions of the plant exhibit no apparent changes initially. However, as the duration of the infection progresses, the number of root lesions gradually increases, and there is a significant reduction in the number of lateral roots. This decline adversely affects the root system's capacity for water and nutrient transport, leading to wilting and water deficiency in some of the above-ground leaves. Consequently, these leaves may wither and abscise, ultimately resulting in the death of the plant.

5 Prevention and control recommendations

Given the characteristics of *F. incarnatum*, which primarily affects coffee seedlings, and the fact that the pathogens predominantly originate from the seedling substrate or the roots of other plants, it is essential to conduct pathogen detection in the soil of nurseries, seedling substrates, or planting bases during the initial stages of seedling cultivation or planting. If *F. incarnatum* is detected, it is advisable to employ high-temperature treatments, as the lethal temperature for the mycelia of this pathogenic fungus is 61 ℃ for 10 min, while the lethal temperature for conidia is 56 ℃ for 10 min. Additionally, interplanting or intercropping coffee with associated hosts that harbor *F. incarnatum* should be minimized to reduce the risk of infection.

In light of the invasion mechanism of *F. incarnatum* via conidia originating from wounds on coffee roots, it is imperative to minimize root damage in practical applications. Initially, when selecting seedlings for planting, it is advisable to choose container-grown seedlings that have not yet developed root penetration. This practice helps to prevent root penetration and subsequent root damage. Furthermore, during the transportation of seedlings, it is essential to secure the container-grown seedlings to minimize movement, thereby reducing the risk of root injury during transit. Secondly, seedlings should be handled with care and planted gently. Following the planting process, it is essential to prevent damage to the coffee roots resulting from agricultural activities. Additionally, root pests, such as grubs and crickets, can inflict harm on the roots; therefore, effective control measures for these pests are necessary. Insect traps may be strategically positioned within coffee gardens at a density of 2 – 3 traps per 667 m^2 to effectively capture turtle pests. Additionally, poison baits can be formulated to target crickets. During peak infestations of grub pests, root treatments can be administered using a dilution of 1 500 – 2 000 times of a 300 g/L solution of Chlorantraniliprole · thiamethoxam SC. Alternatively, 5% phoxim GR can be incorporated with 1 kg per 667 m^2 of organic fertilizer as a basal application during the initial planting stage to eliminate larvae.

In the initial stages of coffee root rot, it is advisable to irrigate the roots alternately with a solution of 70% thiophanate-methyl WP diluted at a ratio of 1 000 – 1 500 times, or with a solution of 250 g/L azoxystrobin SC diluted at a ratio of 1 500 – 2 000 times, for a duration of 20 – 25 d, administered continuously for 2 – 3 applications. Concurrently, the application of potent water-soluble fertilizers, such as fulvic acid or humic acid, is recommended to promote root development. In the intermediate and advanced stages of the disease, when foliar wilting occurs due to lack of water, it is advisable to remove the infected plants and dispose of them properly. Following this, new coffee seedlings should be planted after thoroughly turning the planting holes and incorporating quicklime to facilitate high-temperature exposure.

References

[1] FU XF, HU FG, LI GP, *et al.* Weed identification and greening of coffee plantations[M]. Beijing: China Agricultural Press, 2024. (in Chinese).

[2] FU XF, LI GP, LI YN, *et al.* Pests of *Coffea arabica* in Yunnan and their natural enemies[J]. China Plant Protection, 2023, 43(12): 42 – 50. (in Chinese).

[3] FU XF, HU FG, LI GP, *et al.* Integrated pest management of *Coffea arabica*[M]. Beijing: China Agricultural Press, 2024. (in Chinese)

[4] DU LF, ZENG Q, XU J, *et al.* Identification, biological characteristics and indoor fungicide selection of *Fusarium incarnatum* in Hami melon [J]. Journal of Fruit Science, 2022, 39(5): 855 – 869. (in Chinese).

[5] WANG Y, WANG CW, WANG L, *et al.* Identification and biological characteristics of a novel pathogen *Fusarium incarnatum* causing muskmelon fruit fusarium rot[J]. Acta Horticulturae Sinica, 2019, 46(3): 529 – 539. (in Chinese).

[6] SHAN LY. Isolation, identification and diversity analysis of *Fusarium oxysporum* causing stem rot of maize[D]. Beijing: Chinese Academy of Agricultural Sciences, 2018. (in Chinese).

[7] XIAO BW, YU SY, FENG W, *et al.* Isolation and identification of seed borne fungi on *Orychophragmus violaceus* [J]. Acta Agrestia Sinica, 2020, 28(2): 338 – 349. (in Chinese).

[8] YUE Y, XU J, ZHAO F, *et al.* Molecular identification of fungi carried by *Lycium barbarum* from Ningxia[J]. Modern Food Science and Technology, 2019, 35(10): 102 – 109,302. (in Chinese).

[9] LEYVA-MADRIGAL KY, LARRALDE-CORONA CP, APODACA-SÁNCHEZ MA, *et al.* *Fusarium* species from the *Fusarium fujikuroi* species complex involved in mixed infections of maize in northern Sinaloa, Mexico[J]. Journal of Phytopathology, 2015, 164(6): 486 – 497.

[10] GAI XT, YANG RX, PAN XJ, *et al.* First report of *Fusarium incarnatum* causing stalk rot on maize in China[J]. Plant Disease, 2016, 100 (5): 1010.

[11] DING ZL, WU JP, YANG CZ, *et al.* 2018. First report of *Fusarium meridionale* and *Fusarium incarnatum* causing dry rot of Konjac in China [J]. Plant Disease, 2018, 102(1): 247 – 247.

[12] SINGH B, KALHA CS, RAZDAN VK, *et al.* First report of walnut canker caused by *Fusarium incarnatum* from India [J]. Plant Disease, 2011, 95(12): 1587.