

First report of *Geotrichum candidum* causing fruit rot on avocado (*Persea americana* Mill.) in India

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The avocado (*Persea americana* Mill.), an evergreen, subtropical, dicotyledonous tree in the Lauraceae family, is becoming one of India's most valuable fruit crops. Along with other states, they are also grown in Darjeeling and Kalimpong district of West Bengal. In September 2024, a survey was conducted to collect infected fruits from markets of hill areas of Darjeeling, West Bengal, India. Avocado fruits with sour rot along with black to dark brown discoloration were collected. Infected plum showing symptoms of lesions and rot were collected, and a pure fungal culture of the pathogen was obtained and maintained in PDA at the Mycopathology laboratory, Department of Botany, Darjeeling Government College, Darjeeling which was then used Koch's postulate. Based on the presence of arthrospores and conidia in microscopic study, the pathogen could be preliminarily identified as *Geotrichum candidum*. For molecular identification, whole genomic DNA was extracted, and PCR amplification of conserved genes (ITS gene and 28S rRNA large subunit gene) was done using universal primers ITS1/ITS4 and LROR/LR5. All the sequences produced were submitted to the GenBank (accession Nos. PX795739 and PX795758). According to BLAST search, the ITS (PZ326518) and LSU (PZ326524) sequences showed 98.40 and 98.31% similarity to *G. candidum* (OP765495 and OP763666, respectively) and matched 369 bp/375 bp and 846bp/853 bp of each reference sequence, respectively. In the phylogenetic tree, it also pairs with same isolate. These results confirmed the identity of the pathogen as *Geotrichum candidum*. Both morphological and molecular characterization identify the pathogen as *Geotrichum candidum*, which infects avocado growing in Darjeeling Himalaya.

Keywords : Avocado, *Geotrichum candidum*, sour rot,

INTRODUCTION

The avocado (*Persea americana* Mill.), an evergreen, subtropical, dicotyledonous tree in the Lauraceae family, is becoming one of India's most valuable fruit crops. Due to the fruits' excellent nutritional content, demand for avocados has been rising recently. Avocados are grown in the Western Ghats of India, primarily in Karnataka, Tamil Nadu, Kerala, and Maharashtra (Ghosh, 2000).

They are also grown in Sikkim state, Darjeeling and Kalimpong district of West Bengal. In Sikkim, they are grown up to 5000 feet above mean sea level with an average rainfall of 2000 mm and temperatures between 12°C and 30°C (Tripathi *et al.*, 2014). In Darjeeling markets, they are sold

at Rs. 200/kg. Due to the avocado tree's cultural requirements and the existence of pathogen attack, which can be significant production-limiting factors, production costs are extremely high. One such pathogen is *Phytophthora cinnamomi* which causes Phytophthora root rot. Fruit is also exposed to diseases like scab (*Sphaceloma persea*), anthracnose (*Colletotrichum gloeosporioides*), and Cercospora spot (*Pseudocercospora sporapurpurea*) during its developmental stages in the orchard and during harvesting. These diseases cause discoloration of the fruit or the development of postharvest decay, both of which are undesirable on the export market (Marais, 2004). *Geotrichum* (also known as Galactomyces) is a fungal genus characterized by dimorphic colonial morphotypes, which can appear as cream-colored yeast-like forms or mold-like colonies and some species are known as important post harvest pathogen by causing sour rot in stored fruits and vegetables,

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belongs to the family Dipodascaceae under the order Saccharomycetales (Agrios, 2005, Alper *et al.*, 2011; Kurtzman & Robnett, 2013). According to Pitt and Hocking (2009), *G. candidum* is a plant pathogenic species that causes sour rot in citrus fruits, tomatoes, carrots, and other fruits and vegetables. Ripe or overripe fruits and vegetables, especially those stored in moisture-holding packaging and injured tissue are the most vulnerable to infection (Skavia, 2004). In September 2024, a survey was conducted to collect infected fruits from markets of hill areas of Darjeeling, West Bengal, India. Avocado fruits with sour rot along with black to dark brown discoloration were collected (Fig. 1).

MATERIALS AND METHODS

Fifty contaminated fruits collected from field and market were cleaned with tap water, surface sterilized for one minute with 0.1% sodium hypochlorite, rinsed three times with sterile distilled water, and dried for forty-five seconds on filter paper. Fruit segments measuring 4 mm³ were placed on potato dextrose agar (PDA) and incubated at 28 ± 2°C. A portion of spore suspensions of 10-µl (10⁶ spores/ml) of one isolate were poured onto both scratched and intact asymptomatic avocado fruits (replica of three tests) in order to confirm pathogenicity and to fulfil Koch's postulates. As a negative control, healthy fruits were treated with sterile distilled water. Fruits were nurtured in sterile humid compartments at 28 ± 2°C during the two trials following the methods of Saha and Poddar (2026). The internal transcribed spacer region of rDNA (ITS) and large subunit (LSU) regions were amplified and sequenced using universal primers and submitted to the GenBank after proper annotation to confirm molecular identification (Staats *et al.* 2005). To determine the uniqueness of the pathogen phylogenetic tree was prepared by combining ITS and LSU sequence in MEGA software (Das *et al.* 2020).

RESULTS AND DISCUSSION

The pathogen from a typical rotten fruit with black colour spot along with sour odour was separated and isolated by growing on potato dextrose agar (PDA). After 7 days culture at 28 °C in darkness,



Fig. 1: Infected avocado fruit showing disease symptoms.



Fig. 2 : Colony characteristics of *Geotrichumcandidum* isolated from infected avocado.

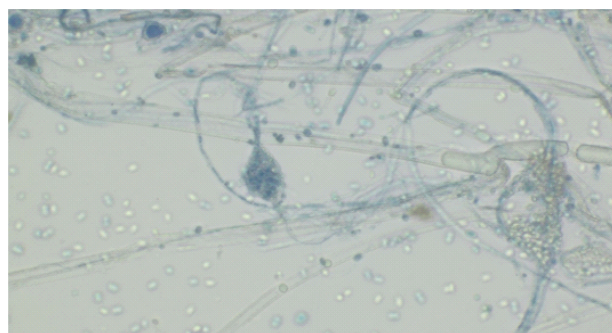


Fig.3: Fungal spores of *G. candidum* (two types of spores, one was long tube-shaped, another was ellipsoidal oval and hyphae).

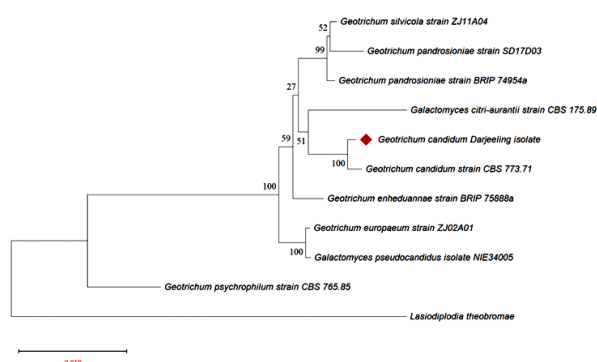


Fig 4: Maximum likelihood phylogenetic tree based on the combined sequences of internal transcribed spacer (ITS) regions and large subunit (LSU), indicating the relationship between *Geotrichum candidum* and the other *Geotrichum* spp. The tree was rooted using *Lasiodiplodia theobromae* as an outgroup. The strain isolated in this study is in red bullet, and the bootstrap values are based on 1,000 replications.

two purified fungal isolates on PDA were examined and white, creamy, spreading, flat and smooth with a pale yellow reverse side was observed (Fig. 2). Additionally, a spherical bulge was seen in the colony's centre. Colony, mycelium, and conidia morphologies were compared for both isolates and showing same result. When the mycelium matured, its end broke into individual spores or spore chains. Additionally, single-cell arthrospores that were cylindrical, barrel-shaped, or ellipsoidal were discovered, with conidia sizes ranging from roughly 3.9–25.4 $\mu\text{m} \times 3.1\text{--}3.5 \mu\text{m}$ ($n = 40$) (Fig. 3). The morphological characteristics were in line with (Thomidiset *al.*'s (2021) description of *Geotrichum candidum*. After five days, scratched infected fruits showed soft, dark-brown color change along with watery material with lesions, while the negative control showed no signs. The fungus that was reisolated from every fruit that was infected had the same morphology as the original cultures. All the sequences produced were submitted to the GenBank (accession Nos. PX795739 and PX795758). According to BLAST search, the ITS (PZ326518) and LSU (PZ326524) sequences showed 98.40 and 98.31% similarity to *G. candidum* (OP765495 and OP763666, respectively) and matched 369 bp/375 bp and 846bp/853 bp of each reference sequence, respectively. In order to further confirmation, the ITS and LSU regions were combined (Das *et al.* 2020), aligned and subsequently used to construct a phylogenetic tree based on a

neighbour joining method. The *Geotrichum* isolate obtained for this study was confirmed to be *Geotrichum candidum* by its position on the phylogenetic tree. (Fig. 4). *G. candidum* infects various fruits and vegetables, including kiwifruit, strawberry, peaches, tomato etc. (Hussain *et al.*, 2016; Lu *et al.*, 2021; Cheng *et al.*, 2021; Wang *et al.* 2025) and infecting potato in India (Ahammed and Dutta, 2026). To our information, this is the first report of *Geotrichum candidum* causing sour rot of avocado (*Persea americana* Mill.), a cultivated plant in Darjeeling Himalaya, India, where prolonged rainy season and long-lasting damp weather provide a constrain for storing of avocado for commercial purpose which demands sustainable solution.

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DECLARATION

Conflict of Interest. Authors declare no conflict of interest.

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