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FOLIAR AND SEEDBORNE FUNGAL PATHOGENS OF TOMATO IN HAWAI'I

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most widely cultivated and consumed vegetable crops globally, ranking among the top in harvested area and production volume. Total world production in 2023 reached 192.32 million metric tons. The United States contributed around 12.37 million metric tons, making it the fourth largest producer. In Hawai'i, tomatoes are grown in commercial farms, small-scale operations, and backyard gardens, contributing to local food supply. The state's tropical climate allows for year-round tomato cultivation. However, environmental conditions such as persistent high temperatures, frequent rainfall, and elevated humidity create conditions that are conducive for the growth and spread of fungal diseases.

Tomatoes are affected by more than 200 diseases, many of which are caused by fungal pathogens. Effective management strategies to enhance productivity and minimize yield losses depend on accurate identification of the most prevalent pathogens. To address this need, we conducted a preliminary survey of foliar and seedborne fungal pathogens affecting tomato genotypes (i.e. varieties, cultivar, growth habit) commonly grown in Hawai'i.

Locally grown tomatoes inside a screenhouse

METHODOLOGY

Foliar Pathogen Detection

Symptomatic tomato leaf samples were collected in Spring 2025 from three tomato growing areas in the island of O'ahu. In the laboratory, small sections from the advancing margins of diseased tissues were aseptically cut, surface sterilized with 10% bleach, and plated on potato dextrose agar (PDA). Plates were incubated for five days under alternating 12-hour light and dark cycles. Pathogens were initially identified based on morphological and cultural characteristics. Identities of representative isolates were subsequently confirmed through PCR amplification of the internal transcribed spacer (ITS) region followed by DNA Sanger sequencing. Fungal pathogen incidence (%) was analyzed to determine their prevalence among tomato genotypes.

Seedborne Pathogen Detection

Locally sourced tomato seeds were plated on PDA, incubated for five days under

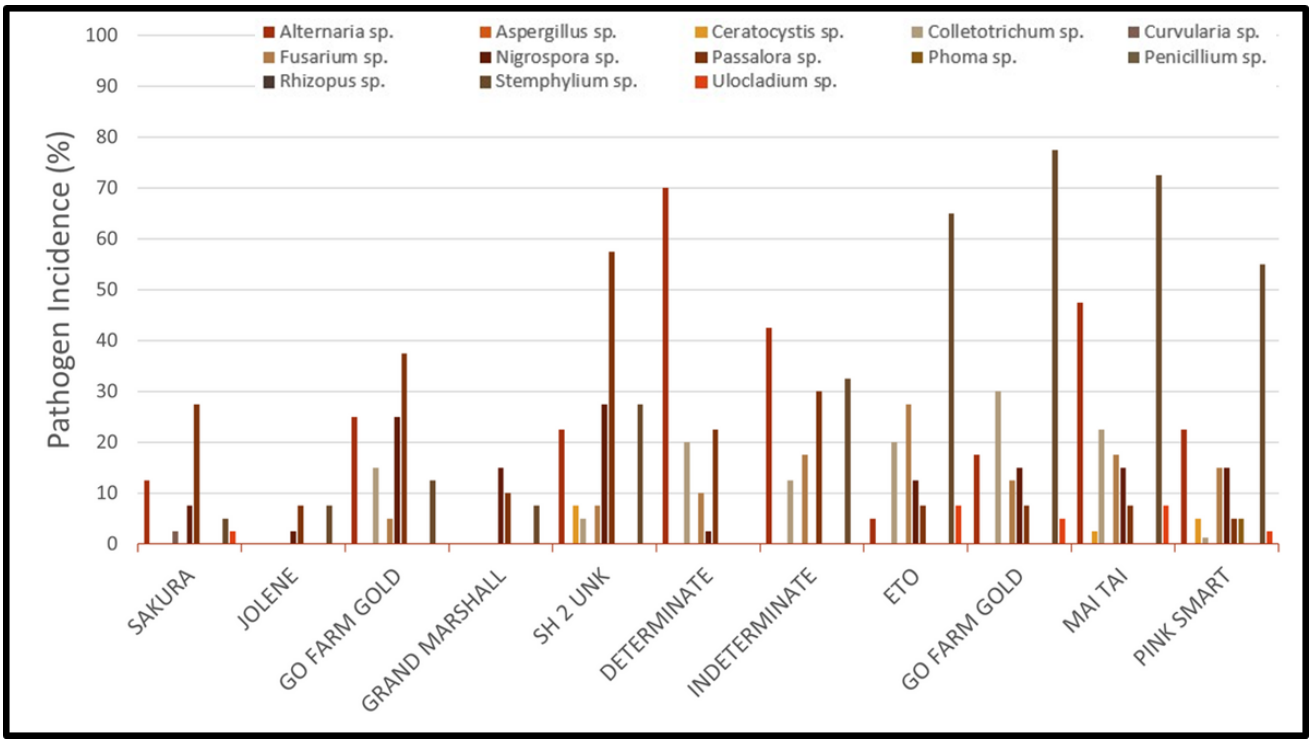
Foliar pathogen detection (left) and seedborne pathogen detection (right) on PDA

alternating 12-hour light and dark cycles, followed by pathogen identification through morphological and cultural characterization. The incidence (%) of fungal pathogens in each tomato genotype was also analyzed.

RESULTS AND DISCUSSION

Multiple genera of fungal pathogens were identified from the tomato leaf samples, with incidence varying among tomato genotypes. Some pathogens were present on certain genotypes but absent on others, even when grown at the same location under identical farm management practices. For example, at one site, *Alternaria sp.* was detected on Sakura, Go Farm Gold, and SH2UNK, but not on Jolene and Grand Marshall.

In plant pathology, the "disease triangle" is a conceptual framework that describes the necessary factors for disease development. This includes a virulent pathogen, a susceptible host, and favorable environment. In the case above, the pathogen is virulent since it infected three out of five genotypes. The environmental conditions were also consistent across all five varieties. This suggests that differences in disease incidence were due to host factors. Host susceptibility to the pathogen can be influenced by its genetic composition, physicochemical properties, nutritional status and development stage.

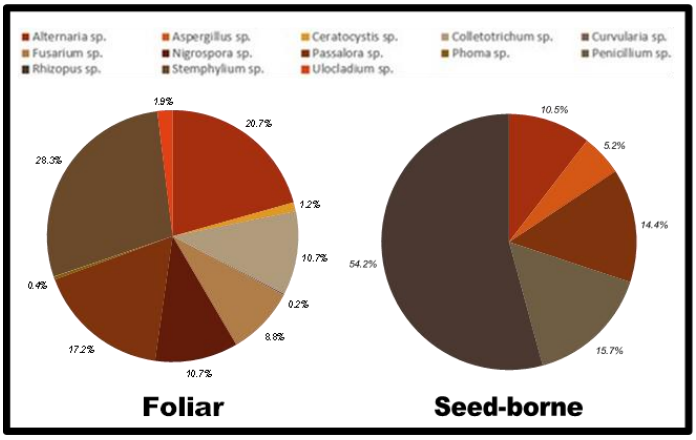


Incidence (%) of detected foliar pathogens per tomato genotype

The incidence of foliar pathogens also varied across locations. For example, *Ulocladium sp.* was detected in Go Farm Gold planted at one site but not in the other, suggesting that certain environmental factors have influenced pathogen occurrence.

Overall, *Stemphylium sp.* was the most prevalent foliar pathogen across all genotypes and locations. The images below show the list of top foliar fungal pathogen genera detected and the probable diseases they can cause.

Seed assays detected the presence of seedborne and storage fungal genera including *Alternaria sp.,* a seed-transmitted pathogen. This indicates that infected seeds could contribute to the initiation and spread of disease.



Overall prevalence of foliar and seedborne fungal pathogens identified in tomato

The most prevalent genus was *Rhizopus* sp., a storage pathogen. Other genera identified from seed sources included *Aspergillus* sp., *Passalora* sp., and *Penicillium* sp.

PREVALENT FOLIAR PATHOGENS DETECTED FROM SURVEYED SITES

Stemphylium sp. culture and spores (top); gray leaf spot symptoms (bottom)

Pathogen: *Stemphylium* spp.

Reported disease: Stemphylium leaf spot or Gray leaf spot

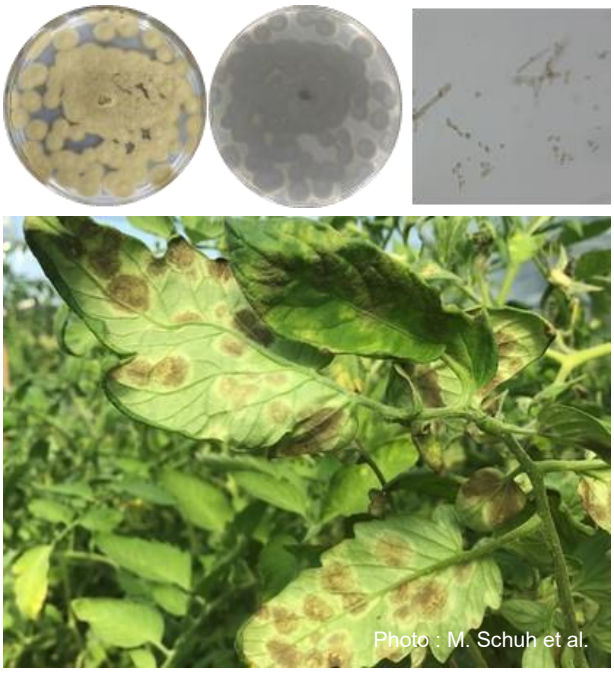
Stemphylium leaf spot, more commonly known as Gray Leaf spot, caused by *Stemphylium solani* and *S. lycopersici* is characterized by small brown to black specks on the leaves that would later develop into grayish brown lesions that are sometimes surrounded by a yellow halo. As the lesions dry, it would eventually crack. This distinguishing feature could be used in identifying the disease from others that have similar-looking symptoms. In severe cases, symptoms can also be observed on petioles and stems. Rapid wilting of leaves followed by defoliation becomes evident as the disease progresses.

Pathogen: *Alternaria spp.*

Reported diseases: Early blight, Alternaria leaf spot, Brown Spot

Early blight or Alternaria leaf spot, is one of the most destructive fungal diseases of tomato caused by *Alternaria solani*. Symptoms of the disease start with small, circular or irregular brown spots, oftentimes surrounded by a yellow halo, that would eventually increase in size and coalesce. Dark brown, concentric rings then appear on the lesions and form the distinct "target" or "bulls' eye" pattern. Tissues surrounding the lesions will eventually turn chlorotic (yellow) and then necrotic (brown and dry). Aside from foliage, the pathogen could also infect the stem and fruits.

Alternaria sp. culture and spores (top); early blight symptoms (bottom)



Passalora sp. culture and spores (top); leaf mold symptoms (bottom)

Pathogen: *Passalora* spp.

Reported diseases: Tomato leaf mold, Leaf spot

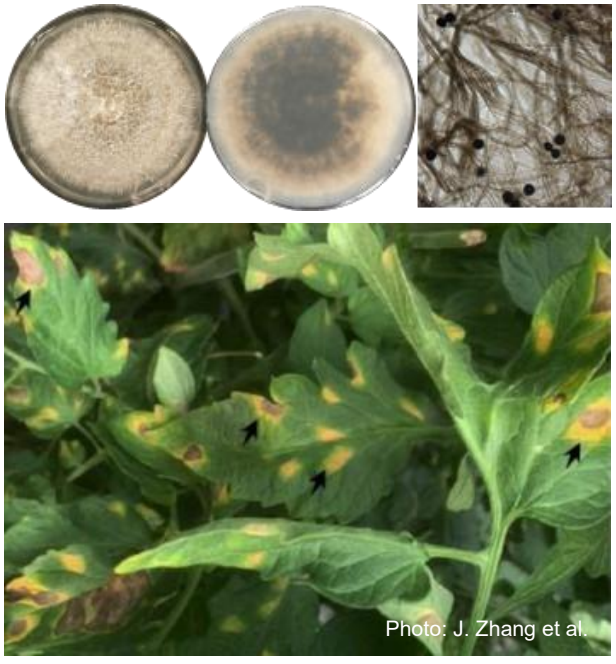
Tomato leaf mold caused by *Passalora fulva* usually occurs on greenhouses or areas with high relative humidity. Symptoms start to appear as pale greenish-yellow spots on the upper side of the leaf and olive-brown velvety mold could develop on the underside of the leaf spots. Infections start with the older leaves first then the younger. When the disease progress, chlorotic (yellow) leaf spots turn brown, leaves wither and eventually die while still adhering to the plant. This pathogen is not known to infect other hosts except tomato.

Pathogen: *Colletotrichum spp.*

Reported disease: Anthracnose

Anthracnose on tomato is more commonly observed on fruits, where it causes severe yield loss and fruit marketability. Symptoms on fruits are usually more readily observable on ripe fruits and can be characterized as small, circular, sunken spots in which the center would become black and form concentric rings. Symptoms can sometimes be observed on older leaves, starting as tiny, brown to dark brown lesions that may eventually coalesce and defoliate the plant. Disease development is favored by wet conditions such as warm rainy weather or overhead irrigations where the spores could be dispersed to healthy plants.

Colletotrichum sp. culture and spores (top); anthracnose symptoms (bottom)



Nigrospora sp. culture and spores (top); leaf spot symptoms (bottom)

Pathogen: *Nigrospora spp.*

Reported disease: Leaf spot

Leaf spot caused by *Nigrospora oryzae* is a fairly new foliar disease in tomato, first observed in greenhouse-cultivated tomato plants in China. Symptoms initially manifest as interveinal chlorosis, followed by browning of the central area, forming elliptical lesions with defined yellow margins. Presence of the disease cause a significant loss in the plant's photosynthetic capability and induce premature leaf drop. *Nigrospora spp.* have been known to infect other crops aside from tomato. Pathogenesis on tomato and host- pathogen interactions are still not clear up to this day.

Pathogen: *Fusarium spp.*

Reported diseases: Fusarium wilt, Fusarium crown and root rot, Foot rot

Currently, there are no known strictly foliar disease caused by *Fusarium* spp. on tomatoes. Most are soilborne pathogens attacking from the root up. The most common species is *Fusarium oxysporum* f. sp. *lycopersici* (Fol) which causes Fusarium wilt, characterized by one-sided yellowing and wilting plant. The pathogen blocks the plant's vascular bundles, disrupting water transport. Crown and foot rot mainly caused by *Fusarium oxysporum* f. sp. *radis-lycopersici* (Forl) also causes yellowing and wilting of foliage, but the discoloration is limited to the lower portion of the stem.

Fusarium sp. culture and spores (top); Fusarium crown and foot rot (bottom)

CONCLUSION & FUTURE DIRECTIONS

This study provides baseline information on prevalent foliar and seedborne fungal pathogens affecting tomatoes in O'ahu. Our findings indicate that both genotype and environmental factors influence pathogen incidence. *Stemphylium* sp. was identified as the most prevalent foliar pathogen, while *Rhizopus* sp. was the most common seedborne pathogen. Since sample collection was limited to spring and to sites on O'ahu, expanding the surveys to additional locations and other islands, as well as sampling across different seasons, would provide a more comprehensive understanding of tomato fungal diseases statewide. Future work will include pathogenicity tests to confirm the ability of the isolates to infect tomatoes, as well as efficacy assays of fungicides and biofungicides against the most prevalent pathogens. All results will provide a foundation for the development of targeted disease management strategies and guide further research on tomato disease dynamics in Hawai'i.

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