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Phyllactinia actinidiae (Jacz.) Bunkina Causes Powdery Mildew on Kiwifruit in India

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Abstract

Kiwifruit is an economically important crop in several countries. Several fungal and bacterial pathogens affect this crop globally. In India, also this crop is growing exponentially in temperate areas. Currently this crop has 5000 hectares area with a production of 13000 metric tonnes. Solan district is a key area for kiwifruit cultivation in Himachal Pradesh. Even though, during the initial years of introduction of this crop it was disease-free. However, with time and increasing cultivation diseases have begun to appear in this crop too. During 2020 growing season, powdery mildew symptoms were observed in the kiwifruit orchards located in the surroundings of Solan District in Himachal Pradesh. Disease incidence level was recorded from 3 to 5%. The samples from affected plants from major orchards were brought to the Fruit Pathology Laboratory of the Department for the identification and pathogenicity studies of causal organism. Based on morphological characterisation, the pathogen was identified as *Phyllactinia actinidiae* belonging to family Erysiphaecae. Pathogenicity of the fungus was established in both potted plants and the detached leaves. Initial symptoms of powdery mildew were observed after 8 days and 14 days on detached leaves and potted plants respectively. Even though, powdery mildew of kiwifruit has been reported from different parts of world, however, this is the first report from India to the best of our knowledge.

Keywords: *Actinidia*, fungus, kiwifruit, *pathogenicity*, *Phyllactinia actinidiae*, powdery mildew

1. Introduction

Actinidia deliciosa Chev., popularly known as kiwifruit, is a deciduous fruiting vine that thrives best in the temperate regions of the world. Kiwifruit has originated in North-Central and Eastern China (Folletta et al., 2019). The commercially significant species of kiwifruit are *A. deliciosa* and *A. chinensis* (Folletta et al., 2019). It is an important fresh fruit, with about 1.5–1.6 million tonnes worldwide annual production (Nikkhah et al., 2015) This fruit has earned itself a place as "China's miracle fruit" and "The Horticultural wonder of New Zealand" among all fruits (Vaidya et al., 2006). However, New Zealand exploited its full economic potential accounting for over 70% of the world trade followed by China (Khachi et al., 2015). It is highly prized for its balanced nutritional composition, being rich in vitamins A, C, and E, folic acid, and a range of phytochemicals (Pang et al., 2020). Several kiwifruit-derived ingredients have been developed in nutraceutical, pharmaceutical, cosmetic, detergent and textile industries (Wang et al., 2020)

Kiwifruit is one of the recently introduced and domesticated crops of Himalayan region (Singh et al., 2008). In India, kiwifruit was first introduced in 1960 at Lalbagh Botanical garden, Bangalore, but the plant did not bear fruits due to unsuitable climatic conditions. Later on, the first bearing of kiwifruit was reported at NBPGR, Shimla in 1969 (Pandey and Tripathi, 2014) after its introduction there. According to NHB (2019) estimates, the kiwifruit area in India is 5000 hectares with production of 13000 metric tonnes.

The kiwifruit crop was regarded as virtually disease-free during the early years of its commercial development (Schroeder and Fletcher, 1967). However, with the increasing kiwifruit monoculture and the rapid expansion of production, disease problems have become numerous and important (Sale, 1984). The information on kiwifruit diseases and their control has remained sparse and rudimentary (Fletcher, 1971; Ford, 1971; Sale, 1984; Meeboon et al., 2015; Xu et al., 2017) in spite of the importance of the crop. The different leaf spots, blights and root rot diseases have been reported from kiwifruit by different workers (Jeong et al., 2008; Koh et al., 2007). However, bacterial blossom blight, bacterial canker and postharvest fruit rots are the major diseases of kiwifruit (Koh et al., 2003).

During May 2020, the powdery mildew disease was found in kiwifruit orchards of Solan district of Himachal Pradesh. The symptoms were observed on the abaxial surface of kiwifruit leaves. An incidence of 3 to 5% on kiwifruit plants was recorded in the affected orchards. The symptoms were

characterised as powdery growth of mycelium on the surface of leaf with erect conidiophores and abundant mass of conidia (Figure 2.). In the later stages of infection, the leaf turned brown in colour with necrotic lesions which ultimately led to shedding of leaves (Figure 1). Infection was more severe during warm and humid climate in the month of May to June. Additional findings showed that this disease in kiwifruit does not commonly occur in Himachal Pradesh (India). The disease has previously been reported from Korea, Japan, China, Taiwan, Russia, and Turkey (Cho et al., 2014; Meeboon et al., 2015; Xu et al., 2017; Farr and Rossman, 2021; Erper et al., 2012).

Figure 1: Powdery mildew infected leaves of kiwifruit

Figure 2: Presence of mycelium on kiwifruit leaf surface

2. Materials and Methods

2.1. Identification of the pathogen

The investigation was undertaken in the June 2020 at the Fruit Pathology Laboratory of the Department of Plant Pathology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) India. The infected samples were examined at the laboratory to study the morphology and pathogenicity of the pathogen. The sporulating fungal structures were dissected from leaves and examined microscopically for morphological characteristics.

2.2. Pathogenicity

The detached and intact leaves on healthy plants were used to confirm pathogenicity of the associated pathogen. The experiment was conducted in completely randomised design with three replications. At least ten leaves were inoculated in each replication. The powdery mildew infected leaves of kiwifruit were used to transfer the inoculum to healthy leaves. The detached leaves were surface sterilized with 1.0 % sodium hypochlorite to inoculate with pathogen. The diseased leaves were kept in-between the two healthy leaves facing abaxial surface. Among intact leaves on healthy plants, the younger healthy leaves were selected, and were gently rubbed with the infected leaves at three different points. The control treatment was maintained for further confirmation. The inoculated leaves and plants were then kept in temperature cum humidity control cabinet at 25±1°C for 14 days.

3. Results and Discussion

3.1. Identification of the pathogen

Chasmothecia (Figure 3) were light yellow in the younger stage of growth which gradually turned brownish black upon maturity. Chasmothecia were spherical to globose in appearance with an average diameter of 185 to 237 µm. Appendages of chasmothecia were 6 to 9 in number, hyaline, aseptate and needle shaped with an average length of 290 to 320 µm and with a bulbous base (Figure 4.). Each chasmothecium contained 8 to 12 unicate asci, 68.3-89.2×25.5-36.4 µm, broadly oval to ellipsoid, curved, with a flexuous foot cell. Ascospores were 2-3 in number and 24.3-37.6 µm×11.3-21.7 µm in size, ellipsoid-ovoid, yellowish-orange and highly guttulate. Conidiophores were erect and cylindrical with the size varying from 150-289×4-8.6 µm. The basal septa of foot cell were elevated and produced conidia singly which were hyaline, obpyriform to clavate with average size of 50-67×25-37 µm. Careful examination revealed that the morphological characteristics of our specimen closely matched the characteristics of the associated pathogen described by Braun and Cook (2012) and Xu et al. (2017). Thus, the pathogen was identified as *Phyllactinia actinidiae* (Jacz.) Bunkina, an obligate parasitic fungus belonging to family Erysiphaceae.

3.2. Pathogenicity

The symptoms on detached leaves appeared 8 days after

inoculation, whereas the symptoms on the intact leaves on the plant appeared 14 days after inoculation. The symptoms on the infected leaves were observed as minute powdery growth of mycelium on the lower surface of the leaf, while the upper surface showed light yellow discolouration. Infection was more severe 12-13 days after the inoculation. The lower surface was covered with mycelium mat and abundant mass of conidia at this stage. The upper surface showed discolouration and development of brown necrotic lesion. In the later stages of infection, the leaves turned brown to black (Figure 4). Similar symptoms were also recorded on the potted plants; however, the rate of symptom development was much slower than the detached leaves. No such symptoms were observed in the control treatment. These findings are similar to those described by Xu et al. (2017) and Cho et al. (2014).

The morphological characters of pathogen and symptom development on the inoculated leaves were similar to those observed on infected plants in the affected orchards.

The pathogen has been reported from different parts of the world, however, based on our findings we report the occurrence of powdery mildew on kiwifruit for the first time in India. Even though, the disease incidence is low at present, however, the occurrence of powdery mildew on kiwifruit in the country is a potential threat to the fledgling kiwifruit industry due to the possibility of its escalation in times to come.

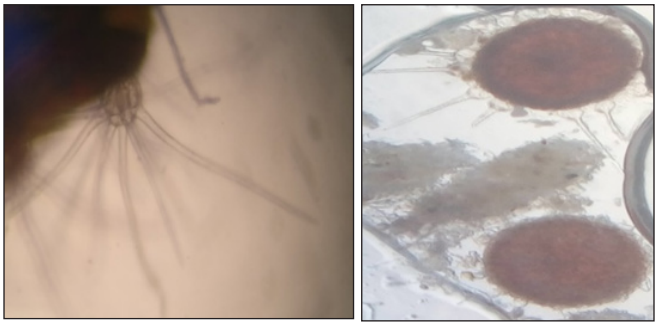

Figure 3: Chasmothecia of *Phyllactinia actinidiae* (Jacz.) Bunkina causing Powdery Mildew on Kiwifruit

Figure 4: Mycelial growth on the abaxial and adaxial leaf surface of kiwifruit after inoculation with *Phyllactinia actinidiae*

4. Conclusion

The incidence of a new disease was recorded at 3 to 5% in the kiwifruit orchards located in the surroundings of Solan, Himachal Pradesh, India. The identity of the causal agent of the disease was confirmed as *Phyllactinia actinidiae* causing powdery mildew, based on morphological characteristics. In the laboratory studies, the initial symptoms of powdery mildew were recorded after 8 days and 14 days on detached leaves and potted plants, respectively, thus, establishing the pathogenicity of the pathogen.

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