Powdery mildew of babaco at Agassiz, British Columbia

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Babaco (*Carica pentagonia*) plants grown in experimental greenhouse ranges at Agassiz, B.C. were observed to be infected with a powdery mildew pathogen during the period of December to April, 1989. The pathogen infected only the leaves of babaco causing a premature yellowing of the leaves and eventual premature leaf abscission when large numbers of colonies were present. The sexual state of the pathogen was not observed so the pathogen was identified using asexual morphological characteristics. The characteristics of the pathogen closely match those of *Oidium caricae-papayae* Yen as described by Boesewinkel (1980). Inoculation of cucumber, kohlrabi and radish seedlings with conidia of the babaco pathogen did not result in colony formation.

Can. Plant Dis. Surv. 71:1, 43-46, 1991.

Des plants de babaco (*Carica pentagonia*) cultivés en serre expérimentale à Agassiz (Colombie-Britannique) se sont révélés infectés par un agent pathogène responsable du blanc au cours de la période de décembre-avril 1989. L'agent pathogène n'infectait que les feuilles de babaco causant un jaunissement et une abscission prématurés des feuilles lorsque le nombre de colonies était suffisamment grand. On n'a pu observer le stade sexué de l'agent pathogène de sorte qu'on l'a identifié au moyen de ses caractères morphologiques asexués. Ces caractères ressemblent étroitement à ceux de *Oidium caricae-papayae* Yen comme les a décrits Boesewinkel (1980). Par contre, l'inoculation de plantules de concombre, de chou-rave et de radis avec des conidies de l'agent pathogène du babaco n'a pas entraînée la formation de colonies.

Introduction

Babaco (*Carica pentagonia*) has been grown for 2 years in experimental greenhouse ranges at the Agriculture Canada research station at Agassiz, B.C. A close relative of the mountain papaya, it is a sterile hybrid between *C. pubescens* Lenne et Kock X *C. stipulata* Badillo (Dawes and Pringle 1983). Plants grow to a height of 2 to 3 metres and bear 50 or more parthenocarpic marrow-like fruit per plant, which may take 6 to 8 months to mature. The objective of the Agassiz babaco program is to determine if babaco can be grown as an alternative crop in commercial greenhouses in south coastal British Columbia.

Epiphytic colonies of powdery mildew were first observed on the upper surfaces of babaco leaves in greenhouses at the Agassiz Research Station in December, 1989 (Fig. 1). As the disease progressed, many colonies were formed on some leaves but compared to *Sphaerotheca fuliginea* on cucumber or *Erysiphe graminis* on wheat or barley, production of conidiophores and conidia was sparse (Fig. 2). Heavy infection caused a premature yellowing of leaves and eventual leaf abscission: however, the pathogen spread slowly and the pruning of severely infected leaves prevented serious yield losses. The pathogen was observed to be restricted to the leaves which is similar to the observation of powdery mildew of babaco made by Boesewinkel (1982b). As the season progressed, infection gradually diminished, until in early April, the pathogen was no longer observed. It would appear that during the spring, the greenhouse daily temperature increased and the pathogen was unable to maintain itself.

Despite the apparent lack of negative effects of the powdery mildew on babaco, the possibility that it was the same powdery mildew that infects cucumber [*Sphaerotheca fuliginea* (Schlecht.: Fr.) Poll. and *Erysiphe cichoracearum* DC: Merat] was cause for concern. If babaco could act as an alternative host, the pathogen could survive the winter and subsequently infect young cucumber plants which are normally planted in late December or early January in commercial greenhouses. It was therefore important to identify the causal agent of the powdery mildew infecting the babaco.

Materials and methods

The sexual state of the powdery mildew pathogen was not observed to form on infected babaco tissue, so the asexual state had to be used for identification. To examine the morphological characteristics of the pathogen, 8 infected leaf pieces from 4 plants were sampled, decolourized in boiling 90% ethanol, and cleared for a minimum of 48 hours in saturated chloral hydrate. The cleared leaf pieces were mounted in Hoyers medium and viewed using a Zeiss Axioplan Universal transmitted light microscope equipped with differential interference contrast optics. Measurements were made to determine the sizes of hyphal cells, haustoria, conidiophores and conidia, the shapes of conidia, conidiophores and hyphal appressoria.

Fresh live conidia were mounted in 3% KOH and examined microscopically to determine the presence or absence of internal fibrosin bodies (Boesewinkel 1980). To examine

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Accepted for publication October 17, 1990.

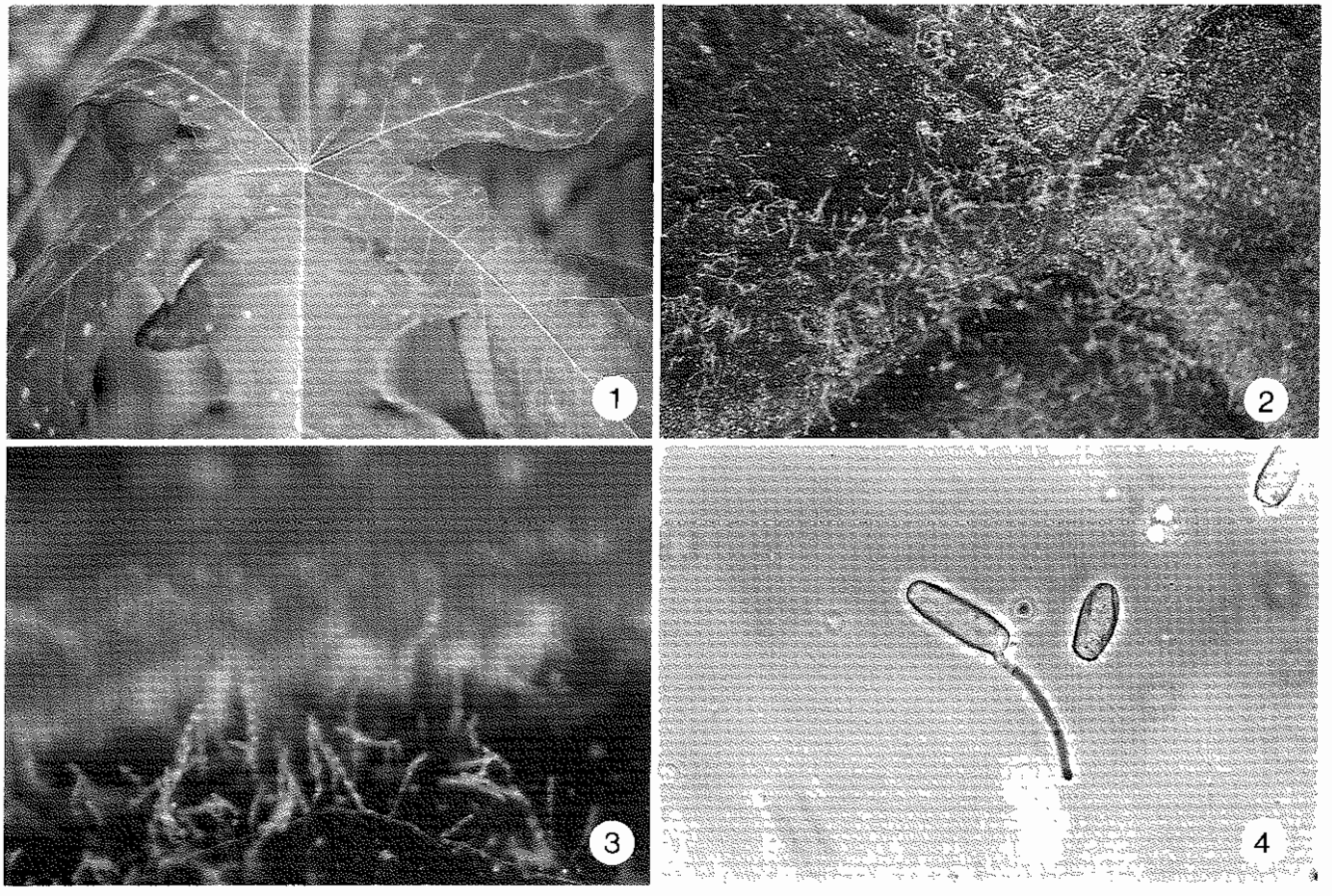

Fig. 1. A babaco leaf with colonies of the powdery mildew pathogen.

Fig. 2. A powdery mildew colony on a babaco leaf showing sparse conidiophore production.

Fig. 3. Short chains of conidia produced by the powdery mildew pathogen.

Fig. 4. A germinating conidium of the babaco powdery mildew pathogen.

the development of the germ tube and appressoria, fresh conidia were inoculated onto 5 glass slides by pressing colonies of the pathogen onto the slides. The inoculated slides were then incubated at 20°C in the dark in individual petri dishes containing a few drops of water. After 24 hours, the conidia were mounted in Hoyer's medium for microscopic examination of the germ tubes and appressoria. Fifteen conidia were examined per glass slide.

Four young seedlings of cucumber (*Cucumis sativus* L.), Kohlrabi [*Brassica oleraceae* var. *gongylodes* L.] and radish (*Rhaphanus sativus* L.) were grown to the expansion of the first true leaf. The first leaf of each seedling was inoculated with conidia of the babaco pathogen by pressing colonies on infected babaco leaves onto the seedling leaves. Plants were examined for symptoms of infection after 2 to 3 weeks of incubation in a greenhouse containing babaco plants infected with the powdery mildew pathogen.

Results

Results of our examinations of the asexual state of the pathogen revealed that hyphal cells (n=24) were (36)-62-(95) X (4)-5-(5)µm, and the hyphae possessed moderately lobed appressoria. Haustoria (n=32) were unlobed globose to pear-shaped and (13)-18-(21) X (9)-14-(23)µm. Conidiophores (n=40) arose from unspecialized foot cells, (23)-34-(48) X (5)-7-(10)µm (Table 1), were unbranched and composed of 3 cells. The size of conidiophore was (55)-71-(100) X (5)-7-(10)µm. Conidia were borne in short chains on the conidiophores (Fig. 3) and the smooth walled conidia (n=80) were (10)-16-(20) X (30)-44-(55)µm. Fibrosin bodies were not detected after mounting the conidia in 3% KOH (Boesewinkel 1980). Straight germ tubes arose from the end of the conidia (n=75) and ended in a slightly enlarged bulbous appressorium (Fig. 4). Inoculation of the cucumber, kohlrabi and radish plants with conidia did not result in symptoms of powdery mildew.

Table 1. Morphological characteristics of powdery mildew fungi reported to infect babaco[1].

Morphological characteristic	Babaco Mildew at Agassiz	*Oidium caricae-papayae* Yen	*Sphaerotheca fuliginea* (Schlecht.:Fr.) Poll.	*Oidium caricae* Noack[2]	*Oidium caricae* Noack[3]	*Oidium caricae* Noack[4]	*Oidium caricae* Noack[5]	*Erysiphe cichoracearum* DC ex Merat	*Erysiphe cruciferarum* OPIZ ex JUNELL
Conidia	short chains (40)-34-(25) X (15)-13-(12.5)	short chains 36-48 X 15.8-19	long chains 25-37 X 14-25	23-25 X 14.5-20	borne singly 40-51 X 10-16	38-51 X 18-20	long chains 26-36 X 15-20	long chains 25-45 X 14-26	borne singly 42-50 X 16-18
Fibrosin bodies	Inconspicuous	Inconspicuous	conspicuous	Inconspicuous	Inconspicuous	Inconspicuous	conspicuous	Inconspicuous	Inconspicuous
Conidiophores	2 septate (100)-70-(55) X (10)-7-(5)	80-160 X 13.2-18	80-100		0-2 septate		0-2 septate 58-80 X 10-13	75-180 X 10-12.5	0-2 septate 70-85 X 8-9
foot cell	(23)-34-(48) X (10)-7-(5)	38-55 X 8.4-12							
Germtubes	arise at end of conidium, staight, Inconspicuous appressorium	arise at end of conidium,	arise at side of conidium, forked tube, Inconspicuous appressorium					arise at end of conidium, staight, Inconspicuous appressorium	arise at end of conidium, forked tube Inconspicuous appressorium
Hyphal appressoria	moderately lobed	moderately lobed	unlobed		multilobed			unlobed	multilobed

[1] Reports of powdery mildew fungi infecting babaco and descriptions of these fungi were obtained from Boesewinkel 1977, 1980, 1982a, 1982b, Yen 1966, Tanda and Braun 1985 and Kapoor 1967a, 1967b. All measurements are in µm.

[2] Noack 1898, as referred to by Boesewinkel 1982a.

[3] Boesewinkel 1982a, teleomorph stated as *Erysiphe cruciferarum* OPIZ ex JUNELL.

[4] Yen 1966.

[5] Tanda and Braun 1985, teleomorph stated as *Sphaerotheca caricae-papayae* Tanda & U. Braun.

Discussion

Asexual morphological characteristics of powdery mildew pathogens have been used for identification in cases where the sexual state is not observed (Boesewinkel 1977, 1980). Boesewinkel (1980) lists the most important characteristics for identification of the asexual state of powdery mildew fungi as the presence or absence of conspicuous fibrosin bodies, shape of hyphal appressoria, size and shape of conidiophores and conidia, and the production of conidia in chains or singly.

Powdery mildew on babaco has previously been reported to be caused by *Oidium caricae* Noack (Boesewinkel 1982a), *E. cichoracearum* DC ex Merat, and *Sphaerotheca fuliginea* (Schlecht. ex Fr.) Poll. (Boesewinkel 1982b). Using the key to species of the Erysiphaceae based on the morphology of imperfect states by Boesewinkel (1980), the pathogen on babaco at Agassiz was identified as *Oidium caricae-papayae* Yen. However, *O. caricae* was not listed in this taxonomic key. Descriptions of *O. caricae* were obtained from Boesewinkel (1982a), Yen (1966) and Tanda and Braun (1985) (Table 1) for comparison with those of the pathogen observed at Agassiz, and with the description of *O. caricae-papayae* by Boesewinkel (1980). Unfortunately, the descriptions of *O. caricae* are not complete and there is some disagreement among the descriptions. For example, different sexual states have been attributed to *O. caricae* (Table 1). Nevertheless, it appears that the morphological characteristics of *O. caricae-papayae* Yen listed by Boesewinkel (1980) gives the best match to the characteristics of the babaco pathogen observed at Agassiz.

The identity of the host plant can also be useful in identifying a powdery mildew pathogen but can lead to misidentification when plants can be infected with more than one powdery mildew. The lack of infection of cucumber, radish and kohlrabi when inoculated with conidia of the babaco pathogen was helpful in identifing the pathogen, since it helped determine that the pathogen is not the crucifer pathogen *E. cruciferarum*. The lack of formation of powdery mildew colonies on cucumber seedlings confirmed that the babaco powdery mildew pathogen is neither of the two cucumber powdery mildew pathogens, *Erysiphe cichoracearum* or *Sphaerotheca fuliginea*. This was re-confirmed by observations in the greenhouse where high populations of the powdery mildew fungus were observed on babaco but not on neighbouring cucumber plants. As well, in other greenhouse ranges, cucumber plants heavily infected with powdery mildew have been grown next to babaco plants that did not show signs of powdery mildew infection. It appears that greenhouse cucumber growers do not have to be concerned about the babaco powdery mildew pathogen.

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