First Report of *Podosphaera xanthii* Melon Race N2 Causing Powdery Mildew on Cucumber in China

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Abstract

Powdery mildew is one of the major diseases affecting yield and quality of cucurbit crops. As part of our disease resistance breeding efforts, we collected powdery mildew from cucumber plants organically grown in a plastic greenhouse located in Xiashan, Weifang, Shandong province of China, N36.495136, E119.444028. Morphological characteristics of conidia were observed under the microscope to confirm species identity, and the race was determined using common melon powdery mildew race differentials. Based on the reactions of the melon powdery mildew differentials this isolate, XS2019, is *Podosphaera xanthii* race N2. In addition, reactions of nine other melon accessions were observed. When the isolate was inoculated on watermelon and squash, we observed typical powdery mildew symptoms in addition to the symptoms on melon differentials. Therefore, the N2 race is pathogenic to all major cucurbit crops grown in China.

Introduction

China is the leading producer and consumer of cucurbit crops in the world. Powdery mildew (PM) often causes significant yield and quality loss for cucurbit production in China, like the rest of the world. PM is probably the most widespread and easily recognizable disease of cucurbits. *Podosphaera xanthii* and *Golovinomyces cichoracearum* cause powdery mildew, and *P. xanthii* is the predominant pathogen (Davis et al., 2007; Tetteh et al., 2007; Zhang et al., 2011; Kim et al., 2013). This disease becomes more difficult to manage in plastic house production in late fall and winter season in China. It causes especially severe damage to watermelon grafted on interspecific squash rootstocks, which are becoming more popular with the advantages of combating soil borne pathogens, providing cold tolerance, and increasing yield (Tirupathamma et al., 2019). PM may affect rootstock and watermelon seedlings before and after grafting during the healing phase, when the relative humidity is almost 100% in plastic house or misting chamber. Fungicide application is an effective method to control powdery mildew disease, however, the development of resistant variety is the most suitable alternative considering the environment impact and emergence of fungicide-resistant strains.

Severe PM symptoms were observed on cucumber (*Cucumis sativus* L.) plants grown in an organic vegetable production farm in Xiashan, Weifang, Shandong province of China, N36.495136, E119.444028. The white sporulation covered the chlorotic angular lesions all over the entire leaf. Infected leaves were collected for pathogen identification and characterization of this PM isolate, XS2019.

Materials and Methods

Pathogenicity Test on Watermelon and Summer Squash: The spores of PM isolate XS2019 were inoculated on watermelon hybrid 'XiaWei105' and summer squash hybrid 'XiaWei8' seedlings grown in pots in a growth room at 23°C and 60% RH. Three non-inoculated seedlings were used as controls. PM symptoms were evaluated 10-days after inoculation.

Race Identification: Seedlings of 14 melon (*Cucumis melo* L.) accessions 'Iran H', 'Top Mark', 'Védrantais', 'PMR 45', 'PMR 5', WMR 29, 'Edisto 47', PI 414723, MR-1, PI 124111, PI 124112, 'PMR 6', 'Nantais Oblong', and AR 5 were used as differential hosts to identify the race of the isolate. PM spores were collected from 'XiaWei105' watermelon leaves 10-days after inoculation for inoculation of the 3rd true leaf of the melon differentials using a small brush. Powdery mildew was

evaluated 10-days after inoculation. Inoculated plants were grown in pots placed in a growth room with 23°C and 60% RH before and after inoculation.

In a second test, seedlings of the 14 melon differentials were transplanted into a plastic greenhouse near the organic vegetable production farm on 28 April 2020 subject to natural PM infection that was evaluated on June 28, 2020, 61 days post-transplanting.

Result and Discussion

Pathogenicity to Cucurbit Crops: The PM isolate XS2019 caused severe symptoms on watermelon plants with white mycelium and chains of conidia covering the entire leaf surface and leaves gradually became more necrotic. The isolate also infected summer squash seedlings and melon differential hosts 'Iran-H', 'Top Mark', 'Védrantais', 'PMR 45', PI 414723, and 'Nantais Oblong', whereas control plants remained symptomless (data not shown). Therefore, this isolate is pathogenic to all major cucurbit crops grown in China, cucumber, watermelon, squash and melon.

Morphological Characteristics: Microscopic observation of conidia in 3% KOH showed that they were ovoid to barrel-shaped, and contained fibrosin bodies commonly found in *P. xanthii* (Braun and Cook, 2012). Therefore, isolate XS2019 is identified as *P. xanthii*.

Race Identification: 'Iran H', 'Top Mark', 'Védrantais', 'PMR 45', PI 414723, and 'Nantais Oblong' were rated as susceptible based on presence of abundant conidia 10-days after inoculation (Figure 1 and Table 1). The other eight accession were rated as resistant based on absence of mycelia and conidia (Figure 1 and Table 1). Small chlorotic angular lesions were, however, observed on WMR 29, PI 124112, 'PMR 5' and 'PMR 6' (Figure 1). PI 124111 exhibited some susceptibility on hypocotyls and cotyledons, but true leaves were resistant.

Reactions of the 14 melon differentials in the plastic greenhouse were consistent with the seedling test conducted in the growth room (Figure 2). Based on the reaction pattern of 'PMR 5', 'PMR 6', WMR 29, 'Edisto 47', and PI 414723, we conclude that isolate XS2019 is *P. xanthii* race N2 (Hosoya et al., 2000; McCreight et al., 2012). This is different from *P. xanthii* race 1, race pxCh1, race 2F, race 5 and race 7 that were previously reported in China (Bao et al., 2008; Liu et al. 2010b; Ma et al., 2011; Zhang et al., 2011; Liu et al., 2010a; Su et al., 2013). To our knowledge, this is the first report of powdery mildew caused by *P. xanthii* melon race N2 on cucumber and other cucurbit crops in China. 'Iran H' was considered susceptible to all melon races reported to date but its reaction to race N2 had not previously been reported. 'Védrantais' and 'Top Mark' are resistant to melon race 0 (Pitrat et al., 1998), but otherwise considered susceptible to all other reported races (McCreight et al., 2012), likewise their reactions to race N2 had not previously been reported.

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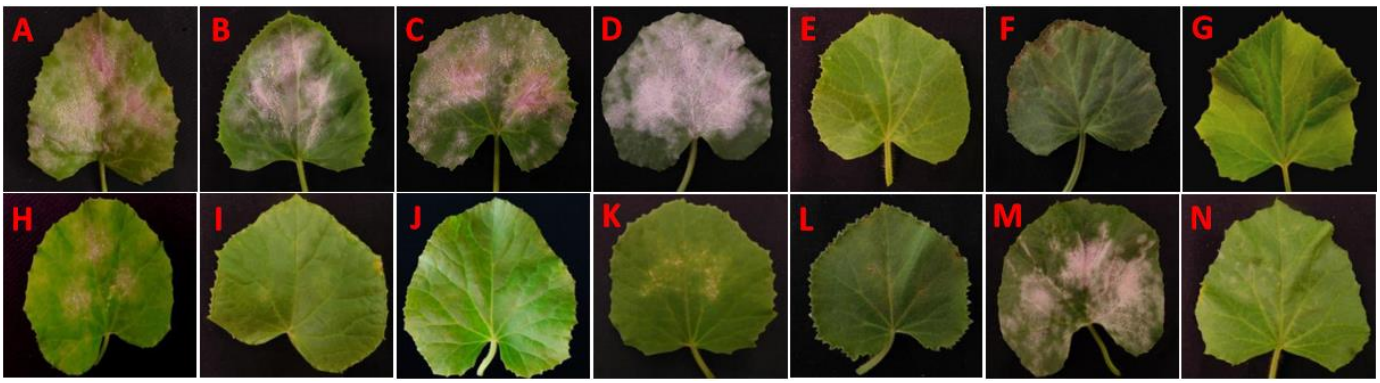

Figure 1: Reactions of 14 melon powdery mildew race differential host seedlings, grown in growth room, to cucurbit powdery mildew isolate XS2019. A, Iran H; B, Top Mark; C, Védrantais; D, PMR 45; E, PMR 5; F, WMR 29; G, Edisto 47; H, PI 414723; I, MR-1; J, PI 124111; K, PI 124112; L, PMR 6; M, Nantais Oblong; N, AR 5.

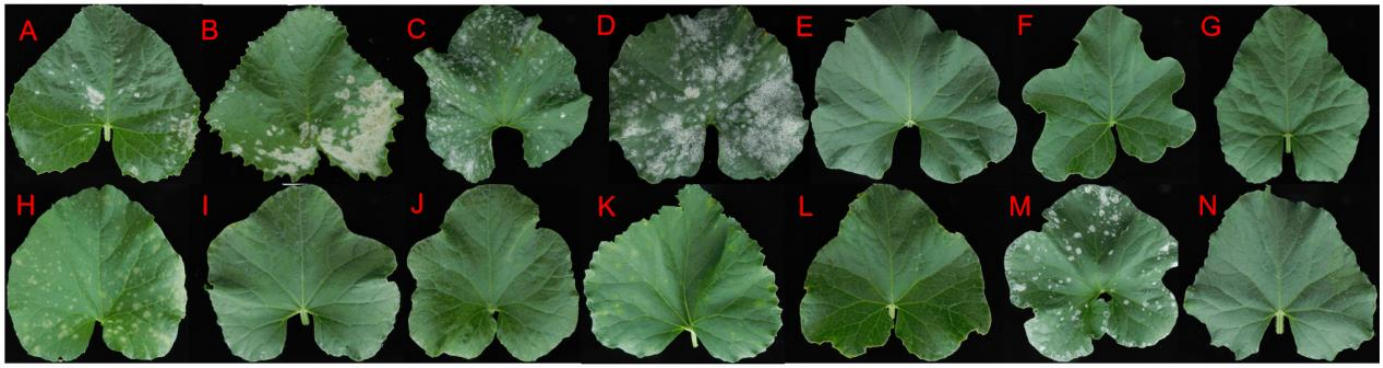

Figure 2: Reactions of 14 melon powdery mildew race differentials to cucurbit powdery mildew isolate XS2019 in a naturally infected greenhouse test. Capital letters A-N represent melon differentials as labeled in Figure 1.

Table 1. Reactions of melon differential hosts to powdery mildew isolate XS2019 in inoculated growth room (seedling) and naturally infected greenhouse (61 days post-transplanting) tests.

Differential host	Seedling	Greenhouse
Iran H	S	S
Top Mark	S	S
Védrantais	S	S
PMR 45	S	S
PMR 5	R	R
PMR 6	R	R
WMR 29	R	R
Edisto 47	R	R
PI 414723	S	S
MR-1	R	R
PI 124111	R	R
PI 124112	R	R
Nantais Oblong	S	S
AR 5	R	R

S = Susceptible; R = resistant