Resistance to Powdery Mildew in Tobacco Induced by Peronospora tabacina

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ABSTRACT

Tobacco plants (cultivar Michal) inoculated with *Peronospora tabacina* exhibited a complete resistance to *Erysiphe cichoracearum* . Eighteen days after exposure (at 20 C) to air-borne conidia of *E. cichoracearum*, 1.3 and 288.3 pustules of powdery mildew per plant developed on *Peronospora*-inoculated and on control (noninoculated) plants, respectively. It is assumed that the biochemical changes induced by *Peronospora* in tobacco plants protect them from a secondary infection with powdery mildew.

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A nonspecific acquired resistance to plant pathogens often develops as a result of inoculation with the same or other plant pathogens. [See literature cited by Lovrekovich (2)]. Rust-TMV cross-protection in beans (5) and reciprocal inhibition of *Peronospora tabacina* - TMV in *Nicotiana* spp. (3) were observed as well.

In this report, we describe an inhibition of powdery mildew development on downy mildew-inoculated tobacco plants.

MATERIALS AND METHODS.—Tobacco (Oriental type, cultivar Michal) plants were grown in peat: sandy loam: vermiculite (2:2:1, v/v) mixture at 25 C in a 14-hour light/day cabinet (about 6,600 lux, supplied by Sylvania Gro-Lux fluorescent lamps, supplemented by incandescent light). Plants (four per treatment) at the five- or the ten-leaf stage were sprayed with conidial suspensions (10^4 conidia per ml) of *Peronospora tabacina* Adam (local race) on the lower surface of the leaves. Plants were covered with moist plastic bags and kept at 15 C in the dark for 12 hours. They were then uncovered, and transferred to a cabinet at 20 C. Noninoculated control plants were sprayed with water and were treated in the same way as the inoculated ones.

Twenty-four, 48, and 96 hours after inoculation, plants were transferred to another growth-chamber in which they were exposed to conidia of *Erysiphe cichoracearum* DC., dispersing from powdery mildew-infected tobacco

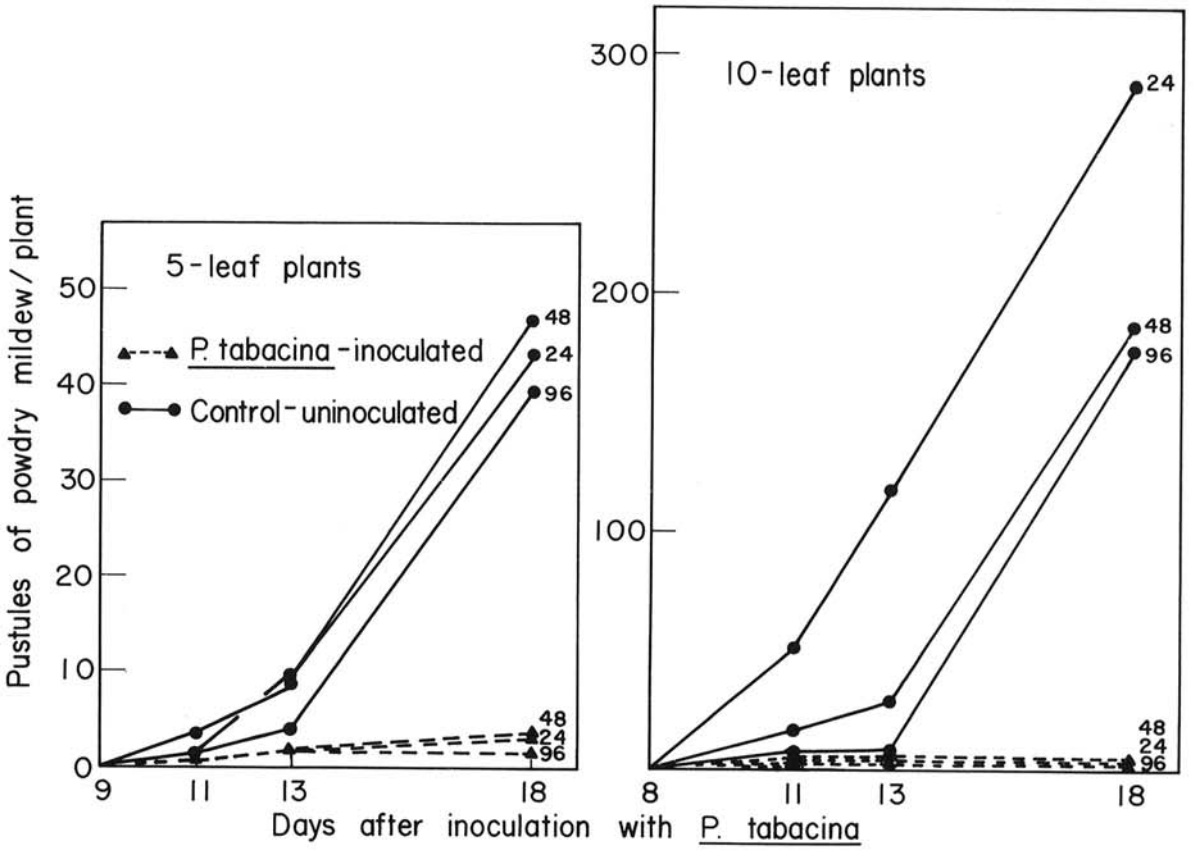

Fig. 1-(A, B) Powdery mildew (*Erysiphe cichoracearum*) development on control (noninoculated) plants and on *Peronospora tabacina*-inoculated plants: **A)** on five-leaf plants; and **B)** on ten-leaf plants. Values are averages for four plants per treatment. Numbers on curves indicate hours after inoculation with *P. tabacina* at which plants were exposed to conidia of *E. cichoracearum*.

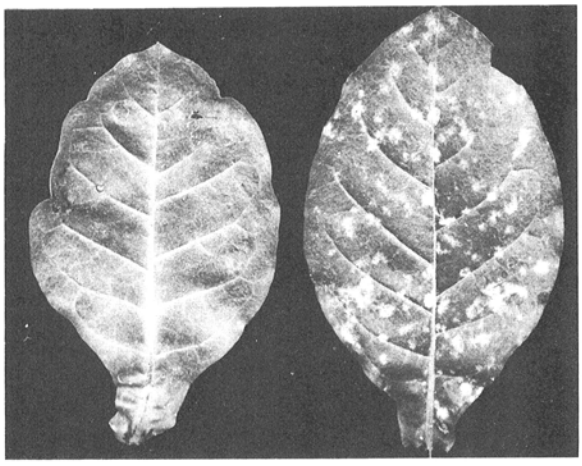

Fig. 2. Powdery mildew development on *Peronospora tabacina*-infected leaf (left) and on uninfected leaf (right) on the 18th day after inoculation. (Leaf No. 5 from a ten-leaf plant).

plants. The location of the plants in this cabinet was changed daily in order to get similar deposition of conidia of powdery mildew.

Eight, 11, 13, and 18 days after inoculation with *P. tabacina*, pustules of powdery mildew were counted on the plants. The experiment was repeated three times using similar conditions. The results were repeatable.

RESULTS.—Downy mildew symptoms appeared on the 7th day after inoculation. Chlorosis gradually intensified (but necrosis did not develop) until the end of the 3rd week after inoculation.

Hyphae and conidia of *E. cichoracearum* were observed initially on the 9th day on the ten-leaf plants and on the 11th day on the five-leaf plants that were not previously inoculated with *P. tabacina* (control-noninoculated plants). No powdery mildew pustules were seen at this stage on all *P. tabacina*-inoculated plants. Number of pustules per plant increased gradually on the control-noninoculated plants until the end of the experimental period (18 days), while very few pustules developed on the *P. tabacina*-inoculated plants (Fig. 1). More pustules per leaf were counted on ten-leaf plants than on five-leaf plants. Ten-leaf plants exposed earliest to conidia of *E. cichoracearum* (24 hours) developed the highest numbers of pustules, as compared to those exposed at a later stage (48 and 96 hours). No such differences were observed on the five-leaf plants. At the end of the experimental period, *P. tabacina*-inoculated plants developed 1.3 - 5.6 pustules of powdery mildew per a ten-leaf plant (1.3 - 3.0 per five-leaf plant) whereas downy mildew-free plants developed 179.6 - 288.3 (39.6 - 47.0) pustules per plant (Fig. 1, 2).

During the experimental period, two to three more leaves developed on each plant. When counted on each leaf individually, the highest number of pustules was found on the 5th and 6th leaf (from the stem base) of the ten-leaf plants, and on the 4th and 5th leaf of the five-leaf plants (Table 1). The lower infected leaves, and the new developing leaves (*Peronospora*-free) of the downy mildew-infected plants bore most of the powdery mildew pustules.

DISCUSSION.—The results reported above clearly demonstrate the existence of an acquired resistance to *E. cichoracearum* in *P. tabacina*-inoculated tobacco plants. Because no mutual cross-protection tests were conducted, there is no evidence whether the induced resistance is reciprocal, or if resistance was transferred to the new developing leaves.

As both colonization of *P. tabacina* and inoculation with *E. cichoracearum* were partially overlapping, it was not possible to determine the exact stage at which *P. tabacina*-infected plants became resistant to the powdery mildew fungus. It is also not known whether conidia of *E. cichoracearum* failed to germinate or if subsequent fungal development was inhibited.

The mechanism involved in this type of induced-resistance is a matter of speculation. Stahmann and

TABLE 1. Inhibition of powdery mildew (caused by *Erysiphe cichoracearum*) development on tobacco induced by *Peronospora tabacina*

Leaf position on stem (from base)	Powdery mildew pustules per leaf (average number)			
	Five-leaf plants[a]		Ten-leaf plants[a]	
	Inoculated	Noninoculated	Inoculated	Noninoculated
1	0	0	0	0.3
2	0	1.2	0	7.9
3	0.1	4.4	0.7	13.6
4	0.3	18.4	0.3	33.0
5	0.7	20.5	0.1	55.3
6	0.8[b]	7.0	0	52.8
7	0.1[b]	1.6	0	40.4
8	0[b]	0	0	27.6
9			0	12.3
10			0.1	8.3
11			0[b]	2.6
12			0[b]	0.1
13			0[b]	0

[a]Age at which plants were exposed to conidia of *E. cichoracearum*.
[b]No downy mildew symptoms observed.

Demorest (4) and Lovrekovich et al. (2) suggested that the increase in peroxidase activity in TMV-infected tobacco plants probably inhibits a secondary infection with *Pseudomonas tabaci*. Kassanis et al. (1) explained the failure of TMV-secondary infection of tobacco in the appearance of at least three new proteins after a primary infection with other viruses. These proteins were found to be identical to those that appeared after injection of polyacrilic acid, which is known to induce resistance against TMV.

Downy mildew-infected tobacco plants exhibit a considerable increase in content of fluorescing materials, in peroxidase activity, and in β-glucosidase activity (Y. Cohen, *unpublished*). It remains to be elucidated whether these or other changes are connected with the induced-resistance to powdery mildew.

Understanding the nature of this resistance may be of importance in biological and chemical control of powdery mildews.

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