Metalaxyl Controls Blue Mold in Flue-Cured Tobacco Seedbeds

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ABSTRACT

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Early development of blue mold in tobacco (*Nicotiana tabacum*) plant beds was controlled with the application of 0.28, 0.56, and 1.12 kg a.i. of metalaxyl per hectare at seeding. However, late-season plant bed losses occurred at test sites in Georgia and South Carolina when metalaxyl was applied only at seeding. Foliar application of metalaxyl at 0.28 kg a.i. per hectare at 7- or 14-day intervals completely controlled blue mold. Plants in plots receiving metalaxyl at seeding were susceptible to systemic *Peronospora hyoscyami* (= *P. tabacina*) infection of petioles and stems. An efficacy-rate response existed with treatments applied at seeding and as a foliar spray. Implications of systemic infection in plant beds are discussed.

The obligate parasite *Peronospora hyoscyami* de Bary (= *P. tabacina* Adam) was first reported in 1921 parasitizing U.S. cultivated tobacco (*Nicotiana tabacum* L.) in Georgia (11). Blue mold, the disease incited by the pathogen, has recurred sporadically throughout the flue-cured and Burley areas and on occasion causes damage to plant beds and field plantings. In 1979, a severe outbreak of blue mold in the tobacco-growing areas of the United States and Canada caused losses estimated in excess of $240 million (11). The recurrence of blue mold in 1980, accompanied by devastating plant bed and field losses, underscores the growing importance of this previously minor disease and our inability to control the pathogen. Early blue mold development in plant beds can result in damage from both foliar and systemic infection. Infected seedlings often result in stunted plants that are prone to lodging (13). The major losses due to blue mold in the flue-cured and Burley areas in 1980 arose from systemic infections of *P. hyoscyami* (2,3,9).

Metalaxyl [*N*-(2,6-dimethylphenyl)-*N*-(methoxyacetyl)-alanine methyl ester] is a systemic fungicide with fungicidal activity against *P. hyoscyami* (7,16). Metalaxyl is effective in controlling *Phytophthora parasitica* var. *nicotianal* (Breda de Haan) Tucker, the cause of tobacco black shank (4,5,8,14), and control of *P. hyoscyami* was observed in research plots designed to evaluate the fungicide for control of black shank during the blue mold epiphytotic of 1979. Metalaxyl has been tested in Australia and Greece for control of both seedbed and field infections of the blue mold fungus. Tsakiridas et al (16) have shown that metalaxyl at high rates controls blue mold in seedbeds as a single drench at 30 g a.i./m^2 or as a spray every 10 days at 30 g a.i./100 L applied in volumes of 1,250–2,000 L/ha. Johnson et al (7) reported that a single application (0.125 g a.i./L at 3,600 L/ha) in the field at transplanting controlled blue mold, as did weekly sprays at the rate of 0.0375 g a.i./L. This study examined the efficacy of metalaxyl for controlling leaf and systemic infections of *P. hyoscyami* in the plant bed relative to time of application and the longevity of blue mold control by metalaxyl.

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MATERIALS AND METHODS

Soil treatments. Tobacco plant beds in Georgia and South Carolina were treated with methyl bromide under plastic sheets at 7.3 kg/100 m^2 for control of weeds, insects, and disease-producing micro-organisms. Seedbeds were prepared, fertilized, and seeded according to state recommendations (6,9). Treatments were replicated three times in a randomized complete block in the two Georgia tests (2.2 and 6.7 m^2 per plot, respectively, for the Coastal Plain Experiment Station and Eldorado locations) and four times in the South Carolina test (9.3 m^2 per plot). Beds were seeded with cv. NC 2326 in Georgia (1 and 2 February for Eldorado and Coastal Plain station, respectively) and with Coker 319 in South Carolina (28 January). Metalaxyl was applied to plant beds at rates of 0.28, 0.56, and 1.12 kg a.i./ha in a spray volume of 888–935 L/ha immediately following seeding.

Foliar treatments. Applications of metalaxyl were made when the tobacco plants reached the four- to six-leaf stage of growth and were continued on a 7-day (Coastal Plain station, GA, and South Carolina) or 14-day (Eldorado, GA) interval until seedlings were of transplanting size. Fungicide rates of 0.14 and 0.28 kg a.i./ha were applied to foliage in the Georgia tests and 0.14 kg a.i./ha in South Carolina. Foliar sprays were applied at 880–935 L/ha. Fungicide treatments were applied 24 and 31 March and 8 and 15 April (Coastal Plain station), 20 March and 7 April (Eldorado), and 21 and 28 March and 4 and 11 April (South Carolina).

Data collection. Leaf blue mold was evaluated by visually rating the percentage of leaf area blighted. Visual ratings were recorded on 2, 6, and 12 May (Coastal Plain station); 9, 17, and 25 April (Eldorado); and 1 and 12 May (South Carolina). Systemic infection of petioles and stems by *P. hyoscyami* was observed at the Coastal Plain station, and the effects of metalaxyl treatments were recorded. Ten plants from each plot were harvested randomly and evaluated for symptoms of systemic infection by *P. hyoscyami* by cutting the petioles and stems longitudinally and recording the percentage with internal vascular necrosis.

RESULTS

Symptoms of blue mold observed in flue-cured tobacco seedbeds included a chlorosis of the upper leaf surface and gray-blue downy mold on the lower surface. Severely infected plants had cupped leaves that turned brown and were killed as the disease progressed. Favorable environmental conditions (3,10) were followed by rapid disease development. Discoloration of the vascular tissue in the petioles and stems (Fig. 1) was evidence of systemic infection just before transplanting. Severely affected plants were usually chlorotic and had puckered, epinastic leaves (3).

The application of metalaxyl at 0.28 kg a.i./ha at seeding (Table 1) completely controlled blue mold at one site in Georgia but not at the other. Disease control was improved at the other site by increasing the metalaxyl application at seeding from 0.28 to 0.56 or 1.12 kg a.i./ha (Table 1). Blue mold increased with time at the Coastal Plain station, especially in treatments receiving metalaxyl only at seeding (Table 1). Blue mold, which developed late in the South Carolina test (14 wk), was not controlled by treatments of metalaxyl at seeding.

Foliar application of metalaxyl at rates of 0.14 and 0.28 kg a.i./ha at 7- or 14-day intervals was effective in Georgia (Table 1). Foliar sprays were discontinued on 11 April in the South Carolina test. Blue mold in the plant bed did not develop until 4 wk after the last metalaxyl application, and residual fungicide from foliar applications was ineffective in reducing blue mold.

Metalaxyl applied at seeding did not prevent symptoms of systemic infection by *P. hyoscyami* at the Coastal Plain station (Table 2). Petiole infection was as high as 70% in beds treated with the lowest rate of metalaxyl. Treatments applied at seeding (0.56, 1.12 kg a.i./ha) significantly ($P = 0.05$) reduced but did not prevent systemic infection of petioles. Infection of stem vascular tissue was less frequent than petiole infection, and both stem and petiole infection were prevented by weekly application of metalaxyl at 0.28 kg a.i./ha.

DISCUSSION

Metalaxyl (applied at seeding at the Eldorado site) controlled blue mold up to 12 wk at rates of 0.28, 0.56, or 1.12 kg a.i./ha. Leaf infection was significantly reduced following metalaxyl treatment at the other Georgia site, but disease symptoms were observed in treated areas. Foliar or systemic infection occurred in two locations following metalaxyl treatment. Metalaxyl is water soluble and may leach out of the soil, resulting in very low levels in the plant during the rapid growth of tobacco in May (13–16 wk after seeding). The 23.4–48.5 cm of rain that fell in March and April may have contributed to the observed lack of control. Transplanting normally occurs 10–12 wk following seeding. Multiple foliar applications controlled the disease for 3 wk after sprays were discontinued. When conditions are favorable for blue mold and beds are maintained for extended periods of time, protective measures in addition to metalaxyl application at seeding may be required.

When seedlings systemically infected by *P. hyoscyami* are transplanted to the field, these plants often have total yield loss (12). These losses occur after major investments in both labor and chemical treatments. Temperature requirements for sporangiospore germination are such that field development of blue mold in the United States is rare, even during years of severe plant bed infections. Systemic infection by *P. hyoscyami* can occur prior to transplanting and does not require secondary spread to cause extensive damage. Previous descriptions of the blue mold disease in the eastern United States (1) have not emphasized the systemic form of the pathogen. The recent increase in the systemic form of the blue mold pathogen as related to environmental conditions (3,10,11) has not been explained. The occurrence of systemic *P.*

Table 1. Tobacco lamina (%) infected with *Peronospora hyoscyami* following treatment of plant beds with metalaxyl at two locations in Georgia and one in South Carolina

		Infection (%)[x]					
		Coastal Plain Station, GA		Eldorado, GA		South Carolina	
Metalaxyl rate (kg a.i./ha)	Application	2 May	6 May	17 Apr	25 Apr	1 May	12 May
Control	···	70.0 a	98.3 a	73.0 a	90.3 a	0	47.0 a
0.28	Surface liquid[y]	6.7 b	13.3 b	0 b	0 b	0	37.0 a
0.56	Surface liquid	2.3 b	5.3 c	0 b	0 b	0	35.0 a
1.12	Surface liquid	0.3 b	1.3 c	0 b	0 b	0	35.0 a
0.14	Multiple foliar[z]	0.0 b	1.0 c	0 b	0 b	0	35.0 a
0.28	Multiple foliar	0.0 b	0.6 c	0 b	0 b	···	···

[x] Mean percentage of leaves infected with *P. hyoscyami* on dates indicated. Means within a vertical column followed by a common letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).

[y] Surface liquid (888–935 L/ha) applied immediately following seeding on 2 February at Coastal Plain station, GA, 1 February at Eldorado, GA, and 28 January at South Carolina site.

[z] Foliar applications made at 7-day intervals (Coastal Plain station, GA, and South Carolina site) and at a 14-day interval (Eldorado, GA), with a total of four and two sprays, respectively, starting at the four- to six-leaf stage.

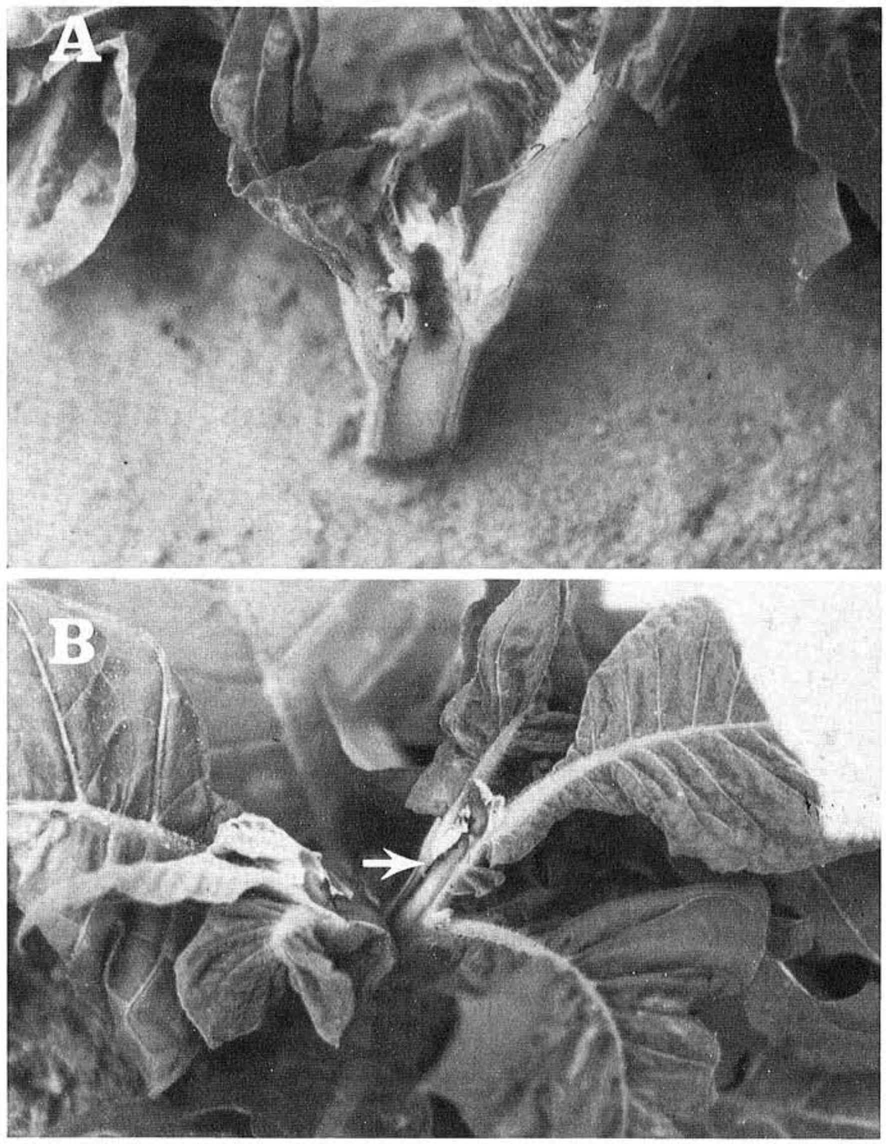

Fig. 1. Symptoms of systemic infection by *Peronospora hyoscyami* on flue-cured tobacco: **(A)** Necrosis of terminal bud induced by *P. hyoscyami*; **(B)** Vascular discoloration (arrow) of leaves and stems infected with *P. hyoscyami*.

Table 2. Tobacco lamina, petiole, and stems (%) infected with *Peronospora hyoscyami* following metalaxyl application of plant beds at the Coastal Plain Experiment Station, GA

Metalaxyl rate (kg a.i./ha)	Time and method of application	Infection (%)[w] 6 May Leaf area infected	6 May Petiole[x] infection	6 May Stem[x] infection	12 May Leaf area infected	12 May Petiole infection	12 May Stem infection
Control	···	23.3 a	63.3 a	23.3 a	8.0 a	96.7 a	13.3 ab
0.28	Surface liquid at seeding[y]	6.3 b	70.0 a	36.7 a	2.0 b	73.3 ab	16.7 a
0.56	Surface liquid at seeding	1.0 b	10.0 b	3.3 b	0.3 c	46.7 b	6.7 ab
1.12	Surface liquid at seeding	0.4 b	10.0 b	3.3 b	0.1 c	10.0 c	0.0 b
0.14	Multiple foliar, four- to six-leaf stage[z]	0.0 b	0.0 b	0.0 b	0.1 c	13.3 c	6.7 ab
0.28	Multiple foliar, four- to six-leaf stage	0.0 b	0.0 b	0.0 b	0.0 c	0.0 c	0.0 b

[w] Mean of three replicates of 10 plants. Means within a vertical column followed by a common letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).
[x] As indicated by symptoms of brown discoloration of vascular tissue in petioles and stems.
[y] Applied at seeding on 2 February 1980.
[z] Applied as foliar spray on 24 and 31 March and 8 and 15 April 1980.

hyoscyami infection following metalaxyl treatment has never been reported in the United States, and the possibility of resistance in *P. hyoscyami* to metalaxyl may warrant investigation (15).

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