Chemical Control of Black Shank of Tobacco

JOHN J. REILLY, Assistant Professor, Virginia Polytechnic Institute and State University, Southern Piedmont Research and Continuing Education Center, Blackstone, VA 23824

ABSTRACT

REILLY, J. J. 1980. Chemical control of black shank of tobacco. Plant Disease 64:274-277.

Selected experimental fungicides were tested for efficacy in controlling black shank of tobacco, a soilborne disease incited by *Phytophthora parasitica* var. *nicotianae*. The chemicals were most effective as transplant water treatments when used on flue-cured cultivars with some resistance to black shank and less effective on susceptible dark-fired tobacco. Propamocarb and metalaxyl at 3.4 and 0.3 kg a.i./ha, respectively, reduced losses by more than 75% compared with the controls. Phenamiphos and aldoxycarb nematicides did not affect efficacy of the fungicides in the combinations tested. Other than the fumigant materials, all fungicides were systemic with specific activity toward Phycomycetes.

Black shank of tobacco, caused by *Phytophthora parasitica* DAST. var. *nicotianae* (Breda de Haan) Tucker, is one of the most destructive diseases of tobacco in Virginia and the United States (4). Four types of tobacco are grown in Virginia, but only burley and flue-cured types have cultivars with high resistance to black shank. A few dark-fired cultivars have moderate resistance, and the sun-cured cultivars have none. Even in burley and flue-cured types where resistance is high, losses of 30% or more are common in fields with high levels of inoculum.

Most of the flue-cured cultivars have some resistance to race 0, the most common race in Virginia, and to race 1, which is also present. Race 2 has been reported only from Africa (3) and race 3, only from Connecticut (2). In Virginia, there is some indication that the usefulness of type 0, 1 resistance is decreasing due to the widespread planting of resistant cultivars, which has probably brought about the selection of more aggressive pathogen strains.

Chemicals available for the control of black shank are multipurpose fumigant materials with some fungicidal activity. Nematodes have been reported to exacerbate black shank (2) by creating wounds through root feeding; therefore, some contact nematicides are occasionally used in conjunction with multipurpose fumigants. However, fumigants are not popular in Virginia because of their human toxicity, a 3-wk waiting period between application and transplanting, and limited effectiveness. Because the black shank pathogen persists in the soil for 5 yr or longer (1), long crop rotations are necessary. These difficulties led to the search for alternate control measures.

Several new chemicals with systemic activity against Phycomycetes have been developed recently. This paper reports the results of 3 yr of field testing these chemicals and others in a black shank nursery containing race 0 of *P. parasitica* var. *nicotianae*.

Contribution 376, Virginia Polytechnic Institute and State University.

Accepted for publication 10 October 1979.

00191-2917/80/03027404/$03.00/0

MATERIALS AND METHODS

Fungicides and nematicides. The following materials were field-tested alone or in combinations for compatibility, phytotoxicity, and effectiveness in controlling black shank of tobacco:

- propyl [3-(dimethylamino) propyl] carbamate monohydrochloride (propamocarb, SN66752), Nor-Am Agricultural Products, Inc., Woodstock, Illinois.
- N-(3-dimethylaminopropyl) thiocarbamic acid S-ethylester hydrochloride (SN41703), Nor-Am Agricultural Products, Inc., Woodstock, Illinois.
- propyl-N-(dimethylaminopropyl) carbamate (SN39744), Nor-Am Agricultural Products, Inc., Woodstock, Illinois.
- N-(2,6-dimethylphenyl)-N-(methoxyacetyl)-alanine methyl ester (metalaxyl, CGA48988), Ciba-Geigy Corp., Agricultural Division, Greensboro, North Carolina.
- potassium N-hydroxymethyl-N-methyldithiocarbamate (Bunema), Buckman Laboratories, Inc., Memphis, Tennessee.
- 1,3-dichloropropene plus chloropicrin (Telone C-17), Dow Chemical, Midland, Michigan.
- ethyl-3-methyl-4-(methylthio) phenyl (1-methylethyl) phosphoramidate (phenamiphos), Mobay Chemical Corp., Agricultural Chemicals Division, Kansas City, Missouri.
- 2 methyl-2-(methylsulfonyl) propionaldehyde 0-(methylcarbamoyl) oxime (aldoxycarb), Union Carbide Corp., Agricultural Division, Jacksonville, Florida.

Field trials. A randomized complete block design with three replicates was used. Plots consisted of single rows of tobacco with 20, 17, and 20 competitive plants per row in 1976, 1977, and 1978,

Table 1. Effect of fungicides on black shank disease control and yield of flue-cured tobacco in 1976

Compound	Rate (kg a.i./ha)	Placement/ formulation[a]	Cultivar	Cured weight[b] (kg/ha)	Disease index[c]	Plants killed (%)
SN41703	3.4	TPW, EC-6	Coker 347	1,839	2.6	3
SN41703	4.5	TPW, EC-6	Coker 347	1,975	0.4	1
SN41703	3.4 + 3.4	TPW + F, EC-6	Coker 347	2,131	1.3	1
SN39744	3.4	TPW, EC-6	Coker 347	1,800	9.1	23
SN39744	4.5	TPW, EC-6	Coker 347	1,808	8.9	17
SN39744	3.4 + 3.4	TPW + F, EC-6	Coker 347	2,017	3.2	5
Metalaxyl	2.2	BR, EC-2	Coker 347	2,404	3.0	6
Metalaxyl	4.5	BR, EC-2	Coker 347	2,372	1.5	1
Control	...	...	Coker 347	773	44.6	80
SN41703	3.4	TPW, EC-6	Speight G-28	2,116	0.0	0
SN41703	4.5	TPW, EC-6	Speight G-28	2,017	2.6	3
SN41703	3.4 + 3.4	TPW + F, EC-6	Speight G-28	2,429	1.5	1
SN39744	3.4	TPW, EC-6	Speight G-28	2,121	0.8	3
SN39744	4.5	TPW, EC-6	Speight G-28	2,111	2.4	3
SN39744	3.4 + 3.4	TPW + F	Speight G-28	1,996	3.2	5
Metalaxyl	2.2	BR, EC-2	Speight G-28	2,163	1.5	5
Metalaxyl	4.5	BR, EC-2	Speight G-28	2,278	1.1	1
Control		...	Speight G-28	1,635	11.9	26
Check		...	Virginia Gold	0	85.5	100

[a]TPW = transplant water, F = foliar spray, BR = broadcast row, EC-6 = 6 lb emulsifiable concentrate, EC-2 = 2 lb emulsifiable concentrate.
[b]LSD_{10} for Coker 347 = 294 kg/ha, LSD_{10} for Speight G-28 = 323 kg/ha.
[c]0 = no plants killed, 100 = all plants killed by first reading.

respectively. Fumigants were applied 3 wk before transplanting to a depth of 15 cm with two chisels 30 cm apart, and the furrows were covered with a drag. Emulsifiable concentrates and wettable powders either were applied in the transplant water at the equivalent rate of 1,870, 2,805, or 3,740 L of water per hectare or were sprayed over the listed row in a 0.5-m band and disked in 7–10 cm just before transplanting. Granules were spread evenly in a 0.5-m band over listed rows, then double-disked to a depth of 7–10 cm. The rows were relisted before transplanting. Foliar treatments were made 3 wk after the crop was transplanted. Foliage was sprayed until the chemical dripped from the leaves. Controls consisted of plants irrigated with 3,740 L per hectare as transplant water.

Plant material. In flue tobacco, high resistance to black shank was represented by cultivar Speight G-28 or McNair 944, moderate resistance by Coker 347, low resistance by Coker 319, and susceptibility by Virginia Gold. In dark tobacco, Virginia 309 was moderately resistant and Hastings was susceptible; high resistance was unavailable.

The number of dead plants was recorded at 2-wk intervals starting 2 wk after transplanting to determine the percentage of kill and the disease index. The disease index was determined by adding the total number of plants with black shank from all biweekly readings within a treatment and dividing by the maximum possible total (found by multiplying the number of plants within a treatment by the total number of readings). Thus, the disease index was weighted over time and gave an idea of how long after inoculation death occurred.

The weight of cured tobacco was calculated by taking 18% of the fresh field weight at the time of harvest. The crop was harvested in three primings at approximately 2-wk intervals.

RESULTS AND DISCUSSION

In evaluating the chemicals for black shank control, cured weight, disease index, and percentage of kill were considered, as one index may be better than the others depending on the conditions during the growing season. As resistant cultivars mature, they become more resistant to the black shank fungus. The 1976 and 1977 seasons were dry and the plants matured slowly; therefore, the disease index was particularly useful in evaluating the progress of the disease over time. In 1978, however, the early growing conditions were ideal and the plants matured rapidly. The plants became resistant early and, although stunted, few developed obvious symptoms or died. Therefore, the efficacy of the chemicals was best reflected in the cured weight.

All materials tested were effective and

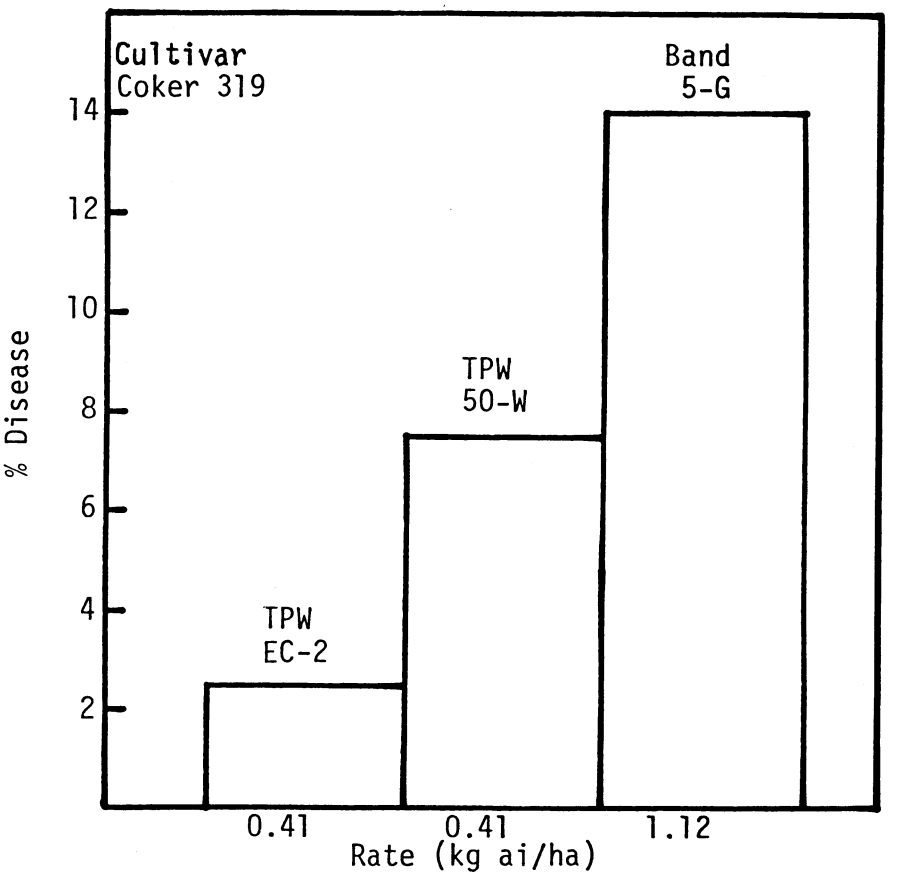

Fig. 1. Percentage of plants killed by black shank in plots treated with varying rates and formulations of CGA48988 experimental fungicide in 1977. TPW = transplant water, Band = 18-in. band, 50-W = 50% wettable powder, 5-G = 5% granules, EC-2 = 2 lb emulsifiable concentrate.

Table 2. Effect of fungicides on black shank disease control and yield of flue-cured tobacco in 1977

Compound	Rate (kg a.i./ha)	Placement/ formulation[a]	Cultivar	Cured weight[b] (kg/ha)	Disease index[c]	Plants killed (%)
Telone C-17	96.5 L/ha	BR-PPF	Coker 319	916	7.1	18.4
Metalaxyl	0.3	TPW, EC-2	Coker 319	1,033	2.9	5.9
Metalaxyl	0.4	TPW, EC-2	Coker 319	1,012	0.7	2.0
Metalaxyl	0.4	TPW, 50W	Coker 319	1,185	2.3	7.8
CGA38140	0.6	TPW, 50W	Coker 319	1,100	2.6	3.9
Metalaxyl	1.1	BAND, 5G	Coker 319	952	6.1	14.3
SN41703	2.2	TPW, EC-6	Coker 319	1,295	0.7	2.0
SN41703	4.5	TPW, EC-6	Coker 319	1,132	0.0	0.0
Propamocarb	2.2	TPW, EC-6	Coker 319	1,118	1.3	3.9
Propamocarb	3.4	TPW, EC-6	Coker 319	1,180	1.0	2.0
Propamocarb	4.5	TPW, EC-6	Coker 319	1,045	0.7	2.0
Propamocarb	3.4 + 3.4	TPW + F, EC-6	Coker 319	956	4.0	6.0
Control	...	...	Coker 319	981	3.0	8.0
Bunema	93.5 L/ha	BR-PPF	Coker 319	936	6.0	14.0
Telone C-17	96.5 L/ha	BR-PPF	Speight G-28	886	2.3	5.9
Metalaxyl	0.3	TPW, EC-2	Speight G-28	932	4.8	10.2
Metalaxyl	0.4	TPW, EC-2	Speight G-28	1,040	0.3	2.0
Metalaxyl	0.4	TPW, 50W	Speight G-28	988	1.3	3.9
CGA38140	0.6	TPW, 50W	Speight G-28	1,024	4.0	10.0
Metalaxyl	1.1	BAND, 5G	Speight G-28	951	2.7	4.0
SN41703	2.2	TPW, EC-6	Speight G-28	963	1.3	2.0
SN41703	4.5	TPW, EC-6	Speight G-28	841	6.0	12.0
Propamocarb	2.2	TPW, EC-6	Speight G-28	905	2.7	6.0
Propamocarb	3.4	TPW, EC-6	Speight G-28	899	1.6	5.9
Propamocarb	4.5	TPW, EC-6	Speight G-28	966	2.0	6.0
Propamocarb	3.4 + 3.4	TPW + F, EC-6	Speight G-28	865	1.0	3.9
Control	...	...	Speight G-28	877	4.7	12.0
Bunema	93.5 L/ha	BR-PPF	Speight G-28	950	2.3	8.0

[a] BR-PPF = broadcast row-preplant fumigant, TPW = transplant water at 3,748 L/ha, F = foliar spray.
[b] LSD_{10} for Coker 319 = 183 kg/ha, LSD_{10} for Speight G-28 = 106 kg/ha.
[c] 0 = no plants killed, 100 = all plants killed by first reading.

Table 3. Effect of fungicides and nematicides alone and in combination on black shank disease control and yield of flue-cured tobacco in 1978

Compound	Rate (kg a.i./ha)	Placement/ formulation[a]	Cultivar	Cured weight[b] (kg/ha)	Disease index[c]	Plants killed (%)
Propamocarb	3.4	TPW, 1,874 L/ha, EC-6	Coker 319	2,498	0.0	0.0
Propamocarb	3.4	TPW, 2,811 L/ha, EC-6	Coker 319	2,641	1.3	1.7
Propamocarb	3.4	TPW, 3,748 L/ha, EC-6	Coker 319	2,575	1.3	1.7
Propamocarb + aldoxycarb	3.4 + 3.4	TPW, EC-6 + 75 WP	Coker 319	2,536	0.0	0.0
Aldoxycarb	3.1	TPW, 75 WP	Coker 319	2,531	1.3	1.7
Metalaxyl	0.6	BAND, EC-2	Coker 319	2,626	0.3	3.4
Metalaxyl	1.1	BAND, EC-2	Coker 319	2,371	0.0	0.0
Metalaxyl	0.6 + 0.1	BAND, TPW, EC-2	Coker 319	2,650	0.0	0.0
Metalaxyl	0.3	TPW, EC-2	Coker 319	2,703	0.0	0.0
Propamocarb + phenamiphos	3.4 + 6.7	TPW, EC-6 + EC-3	Coker 319	2,923	0.0	0.0
Metalaxyl + phenamiphos	0.3 + 6.7	TPW, EC-2 + EC-3	Coker 319	2,722	0.0	0.0
Telone C-17	136 L/ha	PPF	Coker 319	2,586	1.0	1.7
Control	...	...	Coker 319	2,379	0.2	1.7
Propamocarb	3.4	TPW, 1,874 L/ha, EC-6	McNair 944	3,239	0.0	0.0
Propamocarb	3.4	TPW, 2,811 L/ha, EC-6	McNair 944	3,189	0.0	0.0
Propamocarb	3.4	TPW, 3,748 L/ha, EC-6	McNair 944	2,850	0.0	0.0
Propamocarb + aldoxycarb	3.4 + 3.1	TPW, EC-6 + 75 WP	McNair 944	2,956	0.0	0.0
Aldoxycarb	3.1	TPW	McNair 944	2,828	1.3	1.7
Metalaxyl	0.6	BAND, EC-2	McNair 944	2,760	0.0	0.0
Metalaxyl	1.1	BAND, EC-2	McNair 944	2,883	0.0	0.0
Metalaxyl	0.6 + 0.1	BAND + TPW, EC-2	McNair 944	2,796	1.3	1.7
Metalaxyl	0.3	TPW, EC-2	McNair 944	2,701	1.3	1.7
Propamocarb + phenamiphos	3.4 + 6.7	TPW, EC-6 + EC-3	McNair 944	3,119	0.0	0.0
Metalaxyl + phenamiphos	0.3 + 6.7	TPW, EC-2 + EC-3	McNair 944	3,083	0.0	0.0
Telone C-17	136 L/ha	PPF	McNair 944	2,794	1.3	1.7
Control	...	...	McNair 944	2,433	1.3	1.7
Check	...	...	Virginia Gold	140	51.6	98.3

[a]TPW = transplant water at 1,874 L/ha except where noted, BAND = 45-cm band, PPF = preplant fumigant, EC-6 = 6 lb emulsifiable concentrate, 75 WP = 75% wettable powder.
[b]LSD_{10} for Coker 319 = 360 kg/ha, LSD_{10} for McNair 944 = 383 kg/ha.
[c]0 = no plants killed, 100 = all plants killed by first reading.

Table 4. Effect of fungicides on black shank disease control and yield of dark-fired tobacco in 1978

Compound	Rate (kg a.i./ha)	Placement/ formulation[a]	Cultivar	Cured weight[b] (kg/ha)	Disease index[c]	Plants killed (%)
Propamocarb	3.4	TPW, EC-6	Hastings	1,418	5.0	26
Metalaxyl	0.3	TPW, EC-2	Hastings	1,669	3.2	22
Metalaxyl	1.1	BAND, EC-2	Hastings	1,228	9.0	33
Metalaxyl	0.6	BAND, EC-2	Hastings	910	14.0	56
Telone C-17	136 L	PPF	Hastings	958	17.0	56
Control	...	...	Hastings	302	39.0	88
Propamocarb	3.4	TPW, EC-6	Virginia 309	583	21.0	80
Metalaxyl	0.3	TPW, EC-2	Virginia 309	1,305	8.0	45
Telone C-17	136 L	PPF	Virginia 309	484	28.0	80
Control	...	...	Virginia 309	203	45.0	90

[a]TPW = transplant water at 1,470 L/ha, PPF = preplant fumigant, BAND = 45-cm band, EC-6 = 6 lb emulsifiable concentrate, EC-2 = 2 lb emulsifiable concentrate.
[b]LSD_{10} for Hastings = 404 kg/ha, LSD_{10} for VA 309 = 548 kg/ha.
[c]0 = no plants killed, 100 = all plants killed by first reading.

provided a substantial increase in black shank control over the checks in each year of the test (Tables 1–4).

The Nor-Am chemicals SN41703, SN38140, SN39744, and propamocarb are analogs, but recently propamocarb was selected by the company to be advanced for black shank control. Propamocarb was more effective on flue-cured tobacco than on dark-fired (Tables 3 and 4). As judged by the cured weight, better control was obtained on the highly resistant flue-cured cultivar McNair 944 than on the other cultivars. McNair 944 is not immune, however, and suffers some yield depression when infected.

Phytotoxicity was noted with SN39744 and propamocarb at 3.4 and 4.5 kg a.i./ha in 2,805 and 3,740 L of transplant water, respectively. Within 1 wk, the lower leaves in these treatments turned slightly yellow and strappy with some white flecking; they outgrew this condition within 4 wk, however, and appeared normal at harvest time. No compatibility problems were noted between propamocarb and either phenamiphos or aldoxycarb in the 1978 test.

No phytotoxicity was observed using metalaxyl. The high degree of control associated with the low rates of metalaxyl employed in the experiments attests to the activity of the compound. Metalaxyl was effective at 0.4 kg a.i./ha applied in the transplant water on flue-cured tobacco in 1977 (Table 2). Metalaxyl was less effective on dark-fired tobacco (Table 4) but better than all other chemicals tested. When metalaxyl was applied at 0.28 kg a.i./ha in the transplant water of the susceptible cultivar Hastings, a disease index of only 3.2 was recorded even though 22% of the plants were killed. This indicated that infection took place late in the season, with most of the plants being lost in the last week of the season. Control of this degree would allow a grower to harvest the final priming 4–5 days early if a problem developed. Because the most popular dark-fired cultivars have no resistance to black shank, these chemicals should be tested at higher rates than utilized in our tests. Although the dark-fired cultivar Virginia 309 is rated as moderately resistant, it was more susceptible than the flue-cured cultivar Coker 319, which is rated low in resistance (Tables 3 and 4). The resistance of dark-fired cultivars needs to be reexamined using Virginia isolates of *P. parasitica* var. *nicotianae*.

Formulation and method of application affected the efficacy of the chemicals (Fig. 1). Transplant water treatments were more effective than granules used at the same rate. In addition, the emulsifiable concentrate of propamocarb was more effective than the wettable powder applied at the same rate in the transplant water. A foliar application 3 wk after transplanting increased the effectiveness of SN41703 in 1976 but not that of propamocarb in 1977. Apart from the obvious explanation that the two analogs were absorbed at different rates or varied slightly in fungitoxicity, the difference may have been due to weather. In 1976, rain washed the compound from the leaves and may have acted as a midseason soil drench, whereas in 1977, no rainfall occurred until late in the season.

A few selected combinations of fungicides and nematicides were tested to determine if the nematicides altered the effectiveness of the fungicides or caused compatibility or phytotoxicity problems. None of the nematicides was examined for nematicidal activity.

In 1978, phenamiphos was sprayed over the row and raked in just before transplanting. It did not significantly affect the effectiveness of either propa-

mocarb or metalaxyl as determined by final yield, and no phytotoxicity was noted in these combinations.

The nematicide aldoxycarb is not yet labeled for use on tobacco in Virginia. It was placed in the transplant water only with propamocarb. It did not significantly alter the efficacy of propamocarb and was not phytotoxic.

The two chemicals being most researched for use in the control of black shank, propamocarb and metalaxyl, are active against Phycomycetes and represent the first materials with specific and systemic activity against a major disease of tobacco. They are convenient in that they can be used in the transplant water as granulars or as spray treatments and require no waiting period between incorporation and transplanting.

ACKNOWLEDGMENTS

I wish to thank L. D. Moore for advice and review of this manuscript and John Petty for assistance.

LITERATURE CITED

1. JONES, J. L. 1978. Virginia Dark-Fired Tobacco Production Guide for 1978. Ext. Publ. SP-20.
2. LUCAS, G. B. 1975. Diseases of Tobacco. Harold E. Parker and Sons, Fuquay-Varina, NC. 621 pp.
3. McINTYRE, J. L., and G. S. TAYLOR. 1978. Race 3 of *Phytophthora parasitica* var. *nicotianae*. Phytopathology 68:35-38.
4. PRINSLOO, G. C., and G. D. C. PAUER. 1973. Die identifikasie van rasse van Phytophthora nicotianae (B. de Hann) Nicotianae wat in Suid Afrika voorkom. Phytophylactica 6:217-220.
5. TODD, F. A. 1978. Tobacco Disease Loss Evaluation Committee Report, Tobacco Workers Conference, Orlando, FL. 42 pp.