Relative effectiveness of fungicides and nematicides in fusarium blight control

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Fusarium blight is an important and widespread disease of temperate zone turfgrasses(4). Its clinical syndrome consists of two phases: (1) leaf blighting and crown rot, and (2) root rot. The leaf blighting and crown rot phase is first seen as light green patches of turf 2 to 6 inches in diameter. These areas change to a dull reddish brown, then to tan, and finally to a light straw color. The shapes of these areas may be elongated streaks, crescents, or circular patches.

In the later stages of disease development, these circular areas may enlarge to 1 to 3 feet in diameter with center tufts of green, apparently unaffected grass. This combination produces a distinct "frog-eye" effect. Quite commonly, the "frog-eye" pattern may be either absent or in low incidence. In these cases, the overall symptom pattern will be either general blighting or crescents and streaks that are either isolated or impinging on each other.(3,6)

When the root rot phase of Fusarium blight predominates, the plants become stunted, turn pale green in color, and do not recover readily from mowing or adverse weather conditions. The roots of these plants are characterized by a brown to reddish-brown dry rot. As the disease progresses, these roots become darker in color due to colonization by soil saprophytes.(4)

In established stands of turfgrasses, the main sources of inoculum for new infections are dormant fungus tissue in plants that were colonized the previous growing season and Fusarium that is actively growing in the thatch. Certain isolates of the fungi that incite Fusarium blight have been shown to vary in their air temperature requirements for maximum pathogenicity. As a general rule, however, the foliar phase of the disease is more severe during extended periods of high atmospheric humidity with daytime air temperatures from 80° to 95°F. and night air temperatures of 70°F. or above.(3)

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Turfgrass grown under deficient calcium nutrition is more susceptible to Fusarium blight. Also, the disease is more severe under conditions of high nitrogen fertilization (3,5) and when the plants are under soil moisture stress.(5)

Incited by two species of fungi

Fusarium blight is incited by two species of fungi — *Fusarium roseum*(3) and *Fusarium trincinctum*. Both species are known to be transmitted on turfgrass seed(2,3). Also, they are capable of surviving as saprophytes in the thatch and soil.

In addition to differing in their air temperature requirements for maximum pathogenicity, individual isolates of *Fusarium roseum* are also known to vary in their basic pathogenic potential. This variability ranges all the way from being capable of growing only as obligate saprophytes to functioning as highly pathogenic, primary parasites. Also, the overall symptom patterns within the group of turfgrass diseases that are characterized by either foliage blighting or crown rot commonly overlap. For example, in stands of turfgrass under tee or fairway cutting heights, the symptom pattern for Rhizoctonia brown patch and Pythium blight often duplicate those described above for Fusarium blight.

Positive diagnosis of Fusarium blight, then, requires more than observing the association of this particular species with what would appear to be the appropriate symptom pattern of the disease. It also requires that *Fusarium roseum* be isolated from the diseased tissue, grown in pure culture, and then shown to be pathogenic to the turfgrass variety in question. If this procedure is not followed, then the condition in question can not be unequivocably diagnosed as Fusarium blight.(3)

Are nematodes the primary cause of Fusarium blight?

In the initial report on Fusarium blight, it was noted that a positive correlation was not found between the occurrence of the disease and the presence of parasitic nematodes(3). In 1972, however, the possibility was raised that nematodes might be the major causal factor in the development of Fusarium blight. The initiation of this theory was based on two reports. Laughlin and Vargas (7) found that benomyl, a systemic fungicide known to control Fusarium blight, reduced the populatoin level of stunt nematodes *(Tylenchorhynchus dubius)* on Toronto creeping bentgrass *(Agrostis palustris)* when applied at a single application rate of 46.6 ounces of formulated product per 1,000 square feet. Rates less than this failed to reduce the nematode population level.

This report was soon followed by a paper by Vargas and Laughlin that outlined the results of a greenhouse-based study in which stunt nematodes and an isolate of *Fusarium roseum* were used singly and in combination to inoculate the roots of container-grown Merion Kentucky bluegrass *(Poa pratensis)*. The stunt nematode inoculated plants showed a significant reduction in growth rate. The plants inoculated with *Fusarium roseum* alone did not show a significant reduction in growth rate. When Merion bluegrass roots were inoculated with a combination of stunt nematodes and *Fusarium roseum* spores, the growth rate was not significantly less than plants that had been inoculated with stunt nematodes alone (see Table 1). The conclusion the authors drew from this work, however, was "Our results indicate that the disease called Fusarium blight of turfgrasses, previously believed to be incited solely by either *Fusarium roseum* or *F. trincinctum* involves an interaction with *T. dubius.*"

In subsequent field studies, Vargas and associates reported significant reductions in the incidence of Fusarium blight with applications of either 4.5 pounds Vydate, 3 pounds Nemacur, 3 pounds Dasanit, or 3 pounds Mocap per 1,000 square feet. In reporting these results, they stated that they felt they gave" . . . support to the theory that nematodes are the major pathogen in the disease called Fuasarium blight."(12) In order for maximum control to be achieved, they felt that the nematicide " . . . must be applied early in the season before the Fusarium blight symptoms begin to appear."(10)

More recently, this concept that nematodes are the primary causal factor in Fusarium blight development has been stated as follows: "In Michigan, typical symptoms of Fusarium blight of Merion Kentucky bluegrass frequently only occur in the presence of both stunt nematodes and the fungi *Fusarium roseum* and *F. trincinctum*. The stunt nematode increases susceptibility to the fungi and appears to be the predisposing agent for this disease complex."(1)

1978 field study

During July and August 1978, we conducted field trials to (1) evaluate certain nematicides for the control of Fusarium blight and the effect of both fungicides and nematicides on nematode populations in the soil, (2) compare the effectiveness of standard and candidate fungicides for the control of Fusarium blight, (3) determine if a relationship exists between timing of fungicide and/or nematicide applications and disease control with respect to preventive and curative programs, and (4) determine if differences in control occur between one application at a high rate and two applications at low rates of selected fungicides.

The test areas were located on two fairways of a golf course near Blacksburg, Va. Both fairways consisted of irrigated stands of Merion Kentucky bluegrass cut to 1½ inches. Both fairways also had a history of major outbreaks of Fusarium blight.

Four nematicides (Dasanit, Mocap, Nemacur, and Nydate) were tested at rates of active ingredient per 1,000 square feet that have been reported to control Fusarium blight. Five fungicides (Bayleton, CGA 64251, Fungo 50, RP 26019, and Tersan 1991) were included in the trials. In both the preventive and curative programs, single applications of three of the fungicides (Fungo 50, Tersan 1991, and Bayleton) were made at high rates, while two applications were made of each at low rates. All of the nematicides and the two remaining fungicides (CGA 64251 and RP 26019) were made in single applications. In the preventive trials, the time interval between the two split applications was 30 days, while with the curative tests, 12 days lapsed between the two treatments.

In the preventive program, the clinical symptoms of Fusarium blight did not appear until 30 days after the initial fungicide and nematicide treatments. In the curative program, the disease was in high incidence and uniformly distributed over the test area at the time of the first pesticide applications.

For a listing of the materials tested and their active ingredients and manufacturers, see Table 2. The rates and dates of application for the preventive and curative programs are given in Tables 3 and 4.

The individual plots measured 3 by 10 feet. Each treatment was randomized through five replications. All fungicides were applied with a custom built sprayer equipped with a boom and Tee jet nozzles and delivering 30 psi at the nozzles. The dilution rate for the fungicides was 10 gallons of water per 1,000 square feet. The liquid nematicide, Vydate L, was applied with a watering can in the equivalent of 33 gallons of water per 1,000 square feet. The other nematicides were applied with a drop spreader. All nematicides were watered into the soil immediately after application.

Throughout the course of the trials, isolations were made from plants collected from areas in the test sites showing symptoms of Fusarium blight. These consistently yielded pure cultures of *Fusarium roseum*. In laboratory tests, these isolates were found to be highly pathogenic to the foliage of Merion Kentucky bluegrass.

Disease ratings were based on a visual estimate of the percent foliage blighted per plot. In the preventive program, soil samples were collected from each plot 46 days from the time of nematicide application and nematode population determinations made. These counts were based on the number of nematodes per 100 cubic centimeters of soil. All data was subjected to analysis of variance and compared by means of Duncan's multiple range test. The results are presented in Tables 3 and 4.

Timing of fungicide application important

In overview, the results of these tests serve to reinforce the basic principle that effective control of Fusarium blight can only be achieved by the application of fungicides on a preventive

Table 1. Fresh weights of Meriod Kentucky bluegrass roots inoculated with Fusarium roseum and/or Tylenchorhynchus dubius after 90 days. (From Vargas and Laughlin (11).

Treatment	Fresh weight (g)[a]
T. dubius-F. roseum combinations	.31 a
T. dubius alone	.36 a
F. roseum alone	.83 b
Untreated control	1.10 b

[a]Each value is a mean of four replications. Means not followed by the same letter are significantly different at the 5% level according to Duncan's multiple range test.

Table 2. Materials used in the trials — their active ingredients and manufacturers.

Material	Active Ingredients	Manufacturer
Bayleton (WP)	50% 1-(4-chlorophenoxy)-3, 3-dimethyl-l-(IH-1,2,4-triazol-l-yl)-2-butanone	Mobay Chemical Corporation
CGA 64251 (EC)	3 g a.i./fl oz a.i. confidential	Ciba-Geigy Corporation
Dasanit (G)	15% 0,0-diethyl 0-[4-(methylsulfinyl) phenyl] phosphorothioate	Mobay Chemical Corporation
Fungo 50 (WP)	50% dimethyl 4,4'-o-phenylenebis [3-thioallophanate]	Mallinckrodt Chemical Works
Mocap (G)	10% 0-ethyl S,S-dipropyl phosphorodithioate	Mobil Chemical Co.
Nemacur (G)	15% ethyl 3-methyl-4-(methylthio) phenyl (1-methylethyl) phosphoramidate	Mobay Chemical Corporation
RP 26019 (WP)	50% 3-(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidinecarboximide	Rhône-Poulenc Inc.
Tersan 1991 (WP)	50% methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate	E. I. du Pont de Nemours & Co., Inc.
Vydate (L)	2L methyl N'N'-dimethyl-N-[(methylcarbamoyl)oxy]-1-thiooxamimidate	E. I. du Pont de Nemours & Co., Inc.

Table 3. Relative effectiveness of 5 fungicides and 4 nematicides applied on a preventive schedule for control of Fusarium blight of 'Merion' Kentucky Bluegrass.

Treatment	Rate/1000 sq ft[1]	Disease Rating[2]
Nemacur (G)	3 lb	7.0 A
Mocap (G)	5 lb	6.8 AB
Vydate L (L)	1.8 pt	6.8 AB
Dansanit (G)	3 lb	6.0 ABC
Check	——	5.8 ABCD
Fungo 50 (WP)	8 oz	5.0 BCDE
RP 26019 (WP)	8 oz	4.8 CDE
Fungo 50 (WP)	16 oz	4.5 CDE
Fungo 50 (WP)*	4 oz	4.3 CDE
Tersan 1991 (WP)	8 oz	4.0 DE
Tersan 1991 (WP)	16 oz	3.5 E
Tersan 1991 (WP)*	4 oz	1.8 F
CGA 64251 (EC)	12 g a.i.	1.8 F
CGA 64251 (EC)	20 g a.i.	1.8 F
Bayleton (WP)	16 oz	0.3 F
Bayleton (WP)*	4 oz	0.0 F
Bayleton (WP)	8 oz	0.0 F

*All treatments marked with an asterisk were applied twice, July 6 and August 3. All other treatments were applied only once, July 6.
[1]Unless otherwise stated, all dosage levels are given in amount of formulated product.
[2]Disease ratings are based on a visual estimate of the percent turfgrass foliage blighted per plot (0 = no blighting, 10 = 100% blighted). Rating date: August 28. Means not followed by the same letter are significantly different at the 5% level.

Table 4. Relative effectiveness of 5 fungicides and 4 nematicides applied on a curative schedule for control of Fusarium blight of 'Merion' Kentucky Bluegrass.

Treatment	Rate/1000 sq ft[1]	Disease Rating[2]
Mocap (G)	5 lb	6.8 A
Nemacur (G)	3 lb	6.4 A
Dasanit (G)	3 lb	6.4 A
Vydate L (L)	1.8 pt	6.6 A
Check	——	6.2 A
RP 26019 (WP)	8 oz	4.0 B
CGA 64251 (EC)	20 g a.i.	3.8 BC
Fungo 50 (WP)*	4 oz	3.4 BCD
Bayleton (WP)	16 oz	3.2 BCD
Bayleton (WP)	8 oz	2.8 BCDE
CGA 64251 (EC)	12 g a.i.	2.8 BCDE
Bayleton (WP)*	4 oz	2.2 CDEFG
Fungo 50 (WP)	8 oz	2.0 DEFG
Tersan 1991 (WP)*	4 oz	1.2 EFG
Tersan 1991 (WP)	8 oz	1.2 EFG
Fungo 50 (WP)	16 oz	1.0 FG
Tersan 1991 (WP)	16 oz	0.4 G

*All treatments marked with an asterisk were applied twice, August 2 and 14. All other treatments were applied only once, August 2.
[1]Unless otherwise stated, all dosage levels are given in amount of formulated product.
[2]Disease ratings are based on a visual estimate of the percent turfgrass foliage blighted per plot (0 = no blighting, 10 = 100% blighted). Rating date: August 28. Means not followed by the same letter are significantly different at the 5% level.

Table 5. Correlation coefficients for relationship between incidence of Fusarium blight and population levels of parasitic nematodes.

	Fusarium Blight Symptoms	
Nematode Population Levels	Preventive Program	Curative Program
Entire Nematode Population	-.51	-.46
Population of Stunt Nematodes	-.54	-.46

schedule. Also, the precise rates and timing of application must be determined for each fungicide. Bayleton, for example, applied on a schedule of two 4-ounce applications, with the first treatment being made 30 days prior to the onset of symptoms of Fusarium blight, and the second application being made at the time of the first appearance of symptoms, provided 100 percent control of the disease (Figure 1, Table 3). However, when this material was applied at two times this total amount in one 16-ounce application after the clinical phase of the disease was well developed, only 50 percent control was achieved (Table 4).

Tersan 1991, applied at the 8-ounce rate 30 days prior to the onset of symptoms did not control the disease. When used in a schedule of two 4-ounce applications, with one treatment being made 30 days before the appearance of symptoms and the second application at the time of the first appearance of symptoms, approximately 70 percent control of the disease was achieved (Table 3).

The importance of timing is also seen in the performance of Fungo 50. On a schedule of a single application 30 days prior to the appearance of symptoms, the 16-ounce rate was ineffective. When this material was applied on a curative basis at this same rate, however, a high level of disease control was achieved (Tables 3 and 4).

RP 26019 has been reported to provide levels of Fusarium blight control higher than those shown in these tests. It is highly possible that if this material had been applied on a preventive schedule in which the times of application were just prior to the appearance of the clinical phase of the disease, it would have been more effective.

Nematicides failed to control Fusarium blight

Regardless of whether they were used on a preventive or a curative schedule, the nematicides failed to provide any measure of control of Fusarium blight (Figure 1 and Tables 3 and 4). The population counts from the soil samples showed the presence of five ectoparasitic genera (Tylenchorhynchus, Helicotylenchus, Hoplolaimus, Criconemoides, and Tylenchus) and one endoparasitic genus (Pratylenchus). For the purpose of various comparisons, the counts from the non-treated checks and the nematicide treated plots were grouped as follows: (1) total of all nematodes present per 100 cc soil, and (2) number of nemas present for each genus. The data showed a significant decrease in the population level of Helicotylenchus in the Vydate and Mocap treated plots. All other counts from the nematicide treated plots were not statistically different from the checks.

Another comparison made from the total body of data was a determination if a positive correlation existed between the Fusarium blight incidence ratings and the corresponding nematode count for each plot in the entire test series. Two facets of the nematode count were used: (1) the total population level for each plot, and (2) due to the reported relationship with stunt nematode, the population count for this genus for each plot. The correlation coefficient was negative in all cases (Table 5). In other words, there was no relationship between the presence of nematodes, including the stunt nematode, and the incidence of Fusarium blight.

On the basis of these findings, it is our conclusion that plant parasitic nematodes, including the stunt nematode, are not involved in the Fusarium blight syndrome. Fusarium blight is incited by two species of fungi — *Fusarium roseum* and

Figure 1. Effectiveness of certain nematicides and fungicides in the control of Fusarium blight of Merion Kentucky bluegrass. All treatments made on a preventive schedule. Rates below are per 1,000 square feet.

A) *Vydate, 1.8 pint*

B) *Mocap, 5 pounds*

C) *RP 26019, 1 application, 8 ounces*

D) *Bayleton, 2 applications, 4 ounces each*

E) *Tersan 1991, 1 application, 8 ounces*

F) *Non-treated check*

Fusarium tricinctum. Under the environmental conditions described earlier in this paper, the pathogenic strains of these two species are well capable of functioning as primary parasites of turfgrass leaves, crowns, and/or roots. Nematodes are not needed as predisposing agents, nor are they a primary contributor in their own right to the development of Fusarium blight. If an assay of the soil shows that nematodes are present in population levels sufficient to cause stress in the turfgrass plants, then they should be controlled. Their elimination will take away that source of plant stress. However, it will neither eliminate Fusarium blight nor will it reduce its severity. Fusarium blight can only be controlled by controlling the fungi that cause it. □

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