Effect of Benomyl on Sclerotinia Crown and Stem Rot of Alfalfa

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ABSTRACT

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Benomyl at 560 g a.i./ha was applied once, twice, or monthly beginning in October 1974 and ending in February 1975. Symptoms of crown and stem rot of alfalfa (*Medicago sativa*) were first observed in January, and diseased areas increased until the middle of March. The most effective spray schedule was monthly; the most effective single spray was in December. Benomyl applied as a protectant suppressed the severity of crown and stem rot; benomyl applied after symptoms appeared did not retard the spread of the disease. This study shows that one application of an effective fungicide provides control of crown and stem rot. However, yearly variations in temperature and rainfall influenced subsequent experiments, and it was not established that a single application of benomyl in December can be applied regularly to seedling alfalfa to prevent crown and stem rot. More research is needed to relate the appearance of apothecia to fungicide application.

Additional key words: *Sclerotinia trifoliorum*

Crown and stem rot of forage legumes, caused by *Sclerotinia trifoliorum* Erikss., was reported in Germany in 1857 (2). Despite a full description of the fungus, a partial host range, and some control data published in 1872 (8), alfalfa (*Medicago sativa* L.) was not included as a host until 1915 (4). Alfalfa plants of all ages are susceptible to *S. trifoliorum*, but the incidence and severity is greatest in seedlings. Damage varies from season to season and is often scattered within plantings. Losses may involve entire fields or areas as small as 6–8 cm in diameter. The disease can be controlled by deep plowing to bury sclerotia, planting sclerotia-free seed, and maintaining 3- to 4-yr rotations between forage legumes (3,14). Observations have been well documented that some alfalfa and clover plants or varieties sustain less crown and stem rot damage than others (1,5,7,10,12), but crown and stem rot resistance of economic importance is not available. Fungicide control in forage legumes has been successful (6,9,15), but these involved multiple applications. This study was done to determine if single or multiple applications of benomyl interrupt the disease cycle in alfalfa and provide effective control.

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MATERIALS AND METHODS

Alfalfa cultivar Team was broadcast-seeded at 45 kg/ha on 16 September 1974 on a farm near Raleigh, NC, in soils of the Appling-Cecil series previously fertilized and limed according to soil-test and state recommendations. Heavier than normal seeding (22.5 kg/ha) was done to establish a uniform and dense stand of plants. After the stand was established, plots 1.5 × 3 m in the plantings were delineated by applying a contact herbicide in 5-cm strips. Fifteen plots were prepared for each of six replicates, with a 1.5-m border surrounding the experiment.

Benomyl (Benlate) at 560 g a.i./ha was applied to plants monthly, bimonthly, or once between the 14th and 17th day of each month, beginning in October 1974 and ending in February 1975. Time of fungicide application was assigned to plots in a randomized block design. Benomyl was chosen for the test on the basis of its greatest effectiveness in a test with other fungicides the previous year (R. E. Welty, *unpublished*).

Plots were visited once or twice per week after the first application of benomyl. Crown and stem rot damage of plants was determined by counting, measuring, or estimating the dead areas in the plot plantings as they became visible. The symptoms and signs of this disease are distinctive (11) and not easily confused with other pathogens or disorders. Six sets of plots in each replicate were scheduled for benomyl application in March through August 1975. Because these were not sprayed with benomyl, they were analyzed as multiple observations of the unsprayed controls. For plot comparisons, diseased areas were totaled, divided by the plot area, and converted to percentage. An analysis of variance and single degrees of freedom contrasts were performed on the history-adjusted means to test the hypothesis that benomyl-sprayed plots were not different from the unsprayed controls.

RESULTS

Symptoms of crown and stem rot became visible in the plots on 16 January 1975, when damaged areas were 1–2 cm in diameter. Disease occurrence on plants was highly variable within plots and replicates. On 12 February, the circular areas of disease had increased to 6–8 cm in diameter and were easily measured. By mid-March, the areas of damage began to coalesce and became too large and irregular to measure accurately, and damage estimates were made ranging from 10 to 90%. By the end of March and early April, warmer temperatures and longer dry periods contributed to conditions more favorable to the host than to the pathogen, and recovery of the stand occurred from regrowth of nondiseased crown buds. At this time, accurate estimates of disease damage were difficult. The appearance of sclerotia in March and April confirmed damage to be caused by *S. trifoliorum*.

When data collected between 16 January and 11 February were recorded on a field plan, patterns for disease occurrence were not random and it was obvious that some treatments were consistently better than others. Using these data, we found that plant damage occurred more than twice as often in half of the field. Subsequent examinations of cropping history records revealed that the portion of the field containing 59 disease loci had previously been used for an 11-yr study on fertilizing tall fescue (*Festuca arundinacea* Schreb.) and the area containing 149 disease loci had previously been used for alfalfa trials. A regression model was developed to include the

Table 1. Analysis of variance of arc sine transformed data for percentage of Sclerotinia crown and stem rot damage occurring in an alfalfa field with a history of alfalfa or fescue

Source of variations	df	Mean squares (dates, 1975)					
		12 Feb.	25 Feb.	17 Mar.	24 Mar.	28 Mar.	9 Apr.
Treatments (adjusted for history)	9	0.041*[a]	0.031	0.200**	0.118**	0.170**	0.094*
Experimental error	74	0.019	0.027	0.045	0.033	0.043	0.037

[a] Values followed by * or ** have a significant (* = $P = 0.05$ and ** = $P = 0.01$) effect due to history of alfalfa.

Table 2. Efficacy of benomyl (560 g a.i./ha) applied monthly for control of Sclerotinia crown and stem rot of alfalfa

Benomyl application	Disease damage in 1975 (%)[a] (adjusted for crop history)[b]					
	12 Feb.	25 Feb.	17 Mar.	24 Mar.	28 Mar.	9 Apr.
Monthly	0.1	0.1	0.2**	2.0**	1.8**	0.8**
October	0.1	0.1	14.8	11.7	13.5	7.8
November	0.0	0.0	8.5*	10.8	11.1	6.9
December	1.0	0.7	8.7*	13.0	9.2*	7.7
January	3.5	3.9	27.4	28.3	28.3	20.3
February	3.2	1.3	26.3	17.9	23.8	14.7
October + December	0.3	0.1	3.4**	5.3**	3.0**	2.1*
October + January	1.6	2.0	27.1	21.9	22.2	13.8
October + February	6.0**	4.0	21.1	21.6	23.4	14.3
Control[c]	0.7	1.2	25.1	21.1	23.6	12.7

[a] Damage is the percentage of plants in a plot (1.5 × 3 m) affected by crown and stem rot and is the average for six replicates.
[b] Damage was an analysis of the arc sine $\sqrt{Y}$ transformed percentages adjusted for crop history, reconverted to percentage, and tabulated. Numbers in the same column followed by * or ** are significantly different from the control (* = $P = 0.05$ and ** = $P = 0.01$).
[c] Multiple control is the average for six observations per replicate of unsprayed plots.

history effect ($Y = u$ + replicate + treatment + history + error) and the data collected from 12 February through 9 April were analyzed. Data were transformed to arc sine $\sqrt{Y}$ to stabilize error variance, where Y = proportion of the plot that was damaged by the fungus. In every case, the extent of the disease measured was significantly ($P = 0.05$) greater in the plots following alfalfa than in plots following fescue. The percentage of disease damage to alfalfa growing in fields following alfalfa in 1975 was 4.6 (12 February), 4.5 (25 February), 32.6 (17 March), 31.1 (24 March), 30.3 (28 March), and 23.4 (9 April). Comparably, the percentage of damage to alfalfa following fescue in 1975 was 0 (12 February), 0 (25 February), 8.7 (17 March), 7.9 (24 March), 9.3 (28 March), and 3.2 (9 April). The history of alfalfa had obviously increased the incidence of the disease.

When fungicide treatments adjusted for the average field history effect were compared on the six dates (Table 1), there were significant ($P = 0.05$ or $P = 0.01$) differences among them, except for the second reading (25 February 1975). The history effect adjusted for treatment was always highly significant ($P = 0.01$), and all treatment means and treatment mean squares were adjusted for history.

To determine which spray treatments influenced crown and stem rot damage (Table 2), the history-adjusted means from the unsprayed controls were compared with the history-adjusted means from plots sprayed once (October, November, December, January, or February), twice (October and December, October and January, or October and February), or monthly (October through February). The most effective spray schedule was a monthly application. The most effective single spray was that applied in December. The most effective double spray was October and December. The key month to spray for disease control in this experiment was December. Benomyl applied after symptoms were observed was ineffective in preventing further damage. The large amount of damage on 12 February in plots sprayed in October and February was perhaps an experimental anomaly because the plot in one replicate had 60% damage when the remaining five plots averaged 7% damage.

DISCUSSION

December applications of benomyl before symptoms appeared protected alfalfa from crown and stem rot; applications in January or February after symptoms developed did not retard disease development. In North Carolina, apothecia usually develop from sclerotia shortly after 15 October, after the first soaking rain (14). Apothecia continue to develop and discharge ascospores for 4–6 wk after the first apothecia appear. In 1977, apothecia were collected from field plots near Raleigh, NC, from 28 October through 13 December (R. E. Welty, *unpublished*). Primary infection is by ascospores, and secondary infection occurs as mycelium spreads to leaves and stems. Sclerotia form in the spring and lie dormant during the summer. Mycelium grows only to a limited extent in the soil, and new plant infections are rarely initiated by mycelium from sclerotia (13). In this study, benomyl probably controlled the primary inoculum.

Attempts to repeat this work with fall plantings established in 1975, 1976, 1977, and 1979 were unsuccessful. These studies included planting adapted and nonadapted cultivars in uninoculated plots or in plots infested with wheat invaded by mycelium of *S. trifoliorum*. Failure of the disease to develop was attributed to variations in temperature and rainfall.

This work did not establish that a single application of benomyl in December can be applied regularly to seedling alfalfa to prevent crown and stem rot. However, it does indicate that one timely application of benomyl controls crown and stem rot and confirms the finding (16) that timing of treatment is as important as the quantity of fungicide or the number of applications.

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