Evaluation of Foliar Clipping Treatments for Cultural Control of Sclerotinia Crown and Stem Rot in Crimson Clover

ROBERT G. PRATT, Research Plant Pathologist, U.S. Department of Agriculture, Agricultural Research Service, Forage Research Unit, Mississippi State 39762

ABSTRACT

Pratt, R. G. 1991. Evaluation of foliar clipping treatments for cultural control of Sclerotinia crown and stem rot in crimson clover. Plant Dis. 75:59-62.

Foliar clipping treatments were applied to crimson clover at select points in the disease cycle of Sclerotinia crown and stem rot (SCSR), caused by *Sclerotinia trifoliorum*, to determine the potential of single and multiple clippings for cultural control of the disease. During each of 4 yr, crimson clover was seeded in September and grown until April. Foliage was cut in November and January of each year and in February during two of the years. Experiments were performed with and without sclerotia of *S. trifoliorum* added to plots. Estimates of SCSR severity and dry matter yields were obtained in April. During each of 3 yr in which environmental conditions favored SCSR, the November clipping was a significant ($P \leq 0.01$) main effect for reduced disease severity and increased yield. The January clipping was a positive, negative, or nonsignificant main effect in different years. The February clipping was a negative main effect in 2 yr. Interactions between clipping treatments for disease severity or yield usually were not significant. Disease severity was inversely correlated ($P \leq 0.01$) with clover yields in the 3 yr favorable for SCSR. These results indicate that cutting of foliage in November can provide significant cultural control of SCSR in crimson clover. Cutting in January may be beneficial but should not be attempted in locations subject to severe freezes. Cutting in February, and likely at other times after onset of mycelial spread of *S. trifoliorum*, should be avoided.

Sclerotinia crown and stem rot, caused by *Sclerotinia trifoliorum* Eriks., is a major disease of forage legumes in temperate regions throughout the world. In the southeastern United States, the disease is widespread or endemic and may cause extensive losses in fall-planted clovers, alfalfa, peas, and vetches that are grown as hay, grazing, or cover crops (2,9,10,14,17). Differences in susceptibility or tolerance of cultivars have been noted for red clover (14) and alfalfa (16), and species of annual clovers differ in the extent of losses sustained under similar conditions (11). However, no clearly resistant varieties or germ plasms are known for any host species grown in the Southeast.

The disease cycle of SCSR on forage legumes commences in autumn or early winter when sclerotia in soil or thatch germinate carpogenically to form apothecia (5,10,11,14). These eject ascospores that infect host leaves and cause local lesions. *S. trifoliorum* may remain alive within leaf lesions for up to 3 mo or until mycelial growth into surrounding tissue is stimulated by prolonged atmospheric hydration, freeze damage, or senescense of leaves (5,10,14).

Accepted for publication 25 June 1990 (submitted for electronic processing).

This secondary spread of infection initiates the mycelial or rotting phase of the disease. Growth of *S. trifoliorum*, with concurrent rotting of host tissue, progresses from leaves to stems to crowns of infected plants and to adjacent plants under favorable conditions. This results in patches of dead or dying plants that occupy areas from a few centimeters in diameter (17) up to nearly entire stands (1,14). Disease development is terminated by warm temperatures in mid- to late spring (10,17). Sclerotia that form in rotted tissues oversummer and may initiate a new disease cycle the following autumn or in later years (5).

Cultural controls recommended for SCSR on forage legumes include the use of seed not contaminated with sclerotia, crop rotations, and deep plowing to bury sclerotia below a 5-cm depth, which inhibits apothecium formation (1,3,5,13). However, the biological effectiveness and economic value of these practices has not been clearly demonstrated. Crop rotations and use of clean seed in particular may not be practical or effective in areas where *S. trifoliorum* is endemic; sclerotia may remain viable for several years in soil (7,18), and nonleguminous weeds may serve as propagative hosts in the absence of forage legumes (1,7,14). At Mississippi State, Mississippi, SCSR was noted throughout a stand of berseem clover (*Trifolium alexandrinum* L.) planted for the first year on land that had been fallowed or planted to winter wheat for each of the previous 10 yr (R. G. Pratt, *unpublished*). Similar situations have been noted by other authors (1,14).

Cutting or grazing of stands of red clover (*T. pratense* L.) in late autumn has been suggested as a potential cultural practice to control SCSR in Europe (1,5). This is based on empirical observations that disease is often slight in late-cut or grazed stands (6,7,15), but the effectiveness of these practices apparently has not been demonstrated experimentally. A potential for severe winterkill in late-cut stands, with losses greater than might have been caused by SCSR, has been noted (5). In Mississippi, Knight and Hollowell (4) indicated that cutting of crimson clover (*T. incarnatum* L.) in December and February resulted in effective control of SCSR. However, disease severity was not specified in plots of different treatments, and observations were reported for only one growing season.

The purposes of this study were to evaluate the effectiveness of individual and combined foliar clipping treatments, applied at select points in the disease cycle, for cultural control of SCSR in crimson clover and to determine the consistency of control over years. A preliminary report has been presented (8).

MATERIALS AND METHODS

Sclerotia of *S. trifoliorum* were collected by hand from naturally infected crimson and berseem clovers at Mississippi State in March and April of each year and stored, air-dried, at room temperature for 5–6 mo.

Crimson clover cultivar Tibbee was planted by hand in early September of each year in a prepared seedbed in a clay loam soil naturally infested with *S. trifoliorum*. Two adjacent groups of 40 plots each were established; each plot was 0.61 × 0.61 m and received 1 g of seed. Plots were separated by 0.61-m-wide alleys seeded to fescue or ryegrass. From 24 September to 4 October of each year, 70–100 sclerotia were placed evenly among seedlings in surface soil to depths of 0.2–0.5 cm in all plots in one group. The same number were added uniformly each year. These are referred to as "high-disease-intensity" plots; those without sclerotia added, in which disease developed only from sclerotia already present in soil, are referred to as "low-disease-

intensity" plots. The two groups of plots represented distinct experiments each year.

Foliar clipping treatments were applied randomly to plots in each experiment and randomized independently each year. Clipping was applied in mid- to late November before major apothecium formation (10), in early January after major apothecium formation but before noticeable mycelial spread (10,11), and in early February (during 2 yr of the study) after onset of mycelial spread. February clipping was omitted in 1985 because of severe freeze damage to clover and in 1988 because of frequent rains and saturation of soil. In each clipping treatment, foliage was cut with hand-held clippers to just above crowns or growing points of incipient stems and removed from plots. Heights to which plants were clipped were approximately 2.5–3.0 cm in November and 4–8 cm in January and February. Blades of clippers were flame-sterilized after clipping each plot in January and February.

After disease development terminated in early April, SCSR severity was estimated as the percentage of stand in each plot with symptomatic dead plants (11). Dead foliage then was removed from plots by hand, and remaining live foliage was cut at ground level, dried at 110 C for 1–2 wk, and weighed.

Treatments were compared for effects on disease severity and dry matter yields by analysis of variance as a completely randomized design with a 2×2 factorial arrangement of treatments (± November, ± January clippings) in 1985 and 1988, and a $2 \times 2 \times 2$ arrangement (± November, ± January, ± February clippings) in 1986 and 1987. Data were analyzed with the SAS program (12); F values for factorial treatment structure were evaluated and appropriate mean comparisons were based on LSD values at $P = 0.05$.

RESULTS

Newly formed apothecia of *S. trifoliorum* were observed in most high-disease-intensity plots at the time of November clippings each year. Apothecium formation continued through December and into January as in previous studies (10,11). Occasionally, apothecia originating from sclerotia naturally present in soil were observed in low-disease-intensity plots at the same times.

Environmental conditions favored development of SCSR, with ample rainfall during winter and early spring in 1985, 1987, and 1988. In 1985, a succession of moderate to severe freezes (ambient temperatures down to −12 C) occurred from mid-January through early February, and they severely damaged the nondormant clover. Relatively little freeze damage occurred in 1987 and 1988. In 1986, a severe drought prevailed from February through April, and SCSR development was greatly reduced.

Disease severity estimates and dry matter yields are presented in Table 1. Results of statistical analyses for main effects and interactions of treatments are presented in Table 2. In each of the 3 yr favorable for SCSR development, November clipping was a statistically significant main effect for increased yield and lessened disease severity in high-intensity plots, and treatment means differed significantly from those of unclipped plots. The January clipping main effect on yield, disease severity, or both was negative, nonsignificant, or positive in high-intensity plots during the 3 yr. The February clipping was a negative main effect on yield in the 2 yr it was applied. Results of treatments in low-intensity plots generally paralleled those in high-intensity plots, but disease severity was less and yields of clover were greater.

Interactions between treatments usually were statistically nonsignificant or slight as indicated by low F values (Table 2). Combinations of clipping treatments often gave large increases or decreases in yield or disease severity, such as for yield in high-intensity plots in 1988 (Table 1), but these still represented additive rather than interactive effects.

In 1986, when disease development and growth of clover were limited by drought, all treatment main effects on yield were negative or nonsignificant. Lack of soil moisture appeared to limit regrowth of the clover following clipping, so yields were less even when disease was absent or severity was reduced. In contrast, during the 3 yr with sufficient rainfall, regrowth following clipping gave stands that by April appeared equivalent to those of unclipped plots with comparable levels of SCSR.

In 1985, 1987, and 1988, inverse correlations between disease severity and yields over all plots in each experiment, irrespective of treatment, were highly significant ($P \leq 0.01$). In 1986, such correlations were nonsignificant for both high- and low-intensity experiments.

Table 1. Mean severity of Sclerotinia crown and stem rot and mean dry matter yields of crimson clover following application of foliar clipping treatments at two levels of disease intensity during four growing seasons at Mississippi State, MS[a]

			Low disease intensity		High disease intensity	
Year	Clipping treatment[b]	Replicate plots	Disease severity (%)	Dry matter yield (g)	Disease severity (%)	Dry matter yield (g)
1985	O	10	79	213	80	126
	N	10	6	395	56	223
	J	10	92	61	98	15
	N,J	10	65	211	93	52
LSD[c]			16	40	13	46
1986	O	5	31	300	39	321
	N	5	20	216	26	285
	J	5	13	311	19	290
	F	5	11	260	20	252
	N,J	5	14	303	18	316
	N,F	5	9	279	14	281
	J,F	5	13	259	13	272
	N,J,F	5	6	284	13	286
LSD			10	62	11	49
1987	O	5	40	536	70	356
	N	5	5	536	26	450
	J	5	29	451	68	295
	F	5	41	346	68	238
	N,J	5	7	464	17	389
	N,F	5	7	439	31	293
	J,F	5	34	350	65	239
	N,J,F	5	3	409	22	321
LSD			23	109	14	100
1988	O	10	56	222	66	157
	N	10	25	250	42	211
	J	10	43	232	57	210
	N,J	10	10	262	15	303
LSD			9	20	10	35

[a] Crimson clover was planted in 0.61 × 0.61 m plots in September of each preceding year. Low disease intensity refers to unamended field soil, high intensity refers to soil in which sclerotia of *Sclerotinia trifoliorum* were added after planting. Foliar clipping treatments were randomized among plots independently each year. Disease severity represents the percentage of stand in each plot with symptoms of Sclerotinia crown and stem rot in April when yields were obtained.

[b] O = no clipping of foliage, N = foliage clipped in November of preceding year, J = January of indicated year, F = February of indicated year.

[c] LSD = least significant difference at $P = 0.05$.

Table 2. Analyses of variance for main effects and interactions of foliar clipping treatments on disease severity and dry matter yields of crimson clover grown at two levels of disease intensity during four growing seasons at Mississippi State, MS[a]

Year	Clipping treatment[b]	df	Low disease intensity				High density intensity			
			Disease severity (%)		Dry matter yield		Disease severity (%)		Dry matter yield	
			MS[c]	F[d]	MS	F	MS	F	MS	F
1985	N	1	11,717	88.53**	276,058	148.86**	1,161	9.82**	45,428	17.85**
	J	1	6,269	47.37**	284,766	153.55**	4,902	41.44**	199,657	78.45**
	N,J	1	2,155	16.28**	2,544	1.37	151	1.28	9,181	3.61
1986	N	1	170	4.32*	1,381	0.59	81	2.16	706	0.49
	J	1	190	4.83*	6,275	2.69	390	10.41**	410	0.28
	F	1	711	18.08**	1,428	0.61	554	14.77**	9,000	6.20*
	N,J	1	<1	<0.01	4,264	1.83	104	2.80	1,440	0.99
	N,F	1	<1	<0.01	11,594	4.97*	1	0.02	1,796	1.24
	J,F	1	125	3.19	5,452	2.34	87	2.32	336	0.23
	N,J,F	1	55	1.41	3,010	1.29	20	0.53	3,686	2.54
1987	N	1	5,567	27.18**	17,223	2.41	6,899	143.32**	65,772	10.39**
	J	1	107	0.52	20,794	2.91	158	3.28	5,290	0.88
	F	1	<1	<0.01	121,881	17.06**	12	0.25	100,000	16.55**
	N,J	1	44	0.22	270	0.04	44	0.92	462	0.08
	N,F	1	30	0.15	12,110	1.70	72	1.50	1,638	0.27
	J,F	1	18	0.09	10,824	1.52	<1	<0.01	14,364	2.38
	N,J,F	1	57	0.28	1,369	0.19	1	0.02	422	0.07
1988	N	1	4,231	88.24**	8,497	9.06**	4,294	117.08**	52,345	34.86**
	J	1	933	40.75**	1,092	1.80	1,389	42.07**	54,243	35.30**
	N,J	1	28	0.32	9	0.01	356	5.38*	3,822	2.37

[a] Factorial (2 × 2 or 2 × 2 × 2) analyses within years of data presented in Table 1.
[b] N = foliage clipped in November of preceding year, J = January of indicated year, F = February of indicated year.
[c] MS = mean square.
[d] F = ANOVA F value; * = main effect or interaction significant at $P = 0.05$, ** = significant at $P = 0.01$.

DISCUSSION

Results of this study demonstrate that foliar clipping treatments, if applied judiciously at select points in the disease cycle, can provide effective cultural control of SCSR in crimson clover. Because the disease cycle in other forage legumes is known or believed to be similar (11,14,17), it appears that such control also could be obtained in other fall-planted species in the Southeast, However, the timing of events in the disease cycle, especially apothecium formation and primary infection, varies with latitude or environment (10,14,17), so clipping times might have to be altered to obtain comparable results elsewhere.

During the 3 yr of this study in which environmental conditions generally favored SCSR, the most consistent and positive results were obtained with clipping in November. The most likely explanation for this effect is that much of the primary infection court is removed with November clipping, just before major apothecium formation, and primary infection of leaves by ascospores is thereby reduced. This mechanism was also proposed to explain beneficial responses of autumn grazing on SCSR in red clover (5). If the mechanism is true, then equivalent clippings might have to be applied earlier in more northerly latitudes in the Southeast, or later in more southerly latitudes, to antedate apothecium formation, which is stimulated by cool autumn temperatures and rainfall (1,5,10). Other possibly beneficial effects of November clipping treatments involve exposure and drying of the soil surface, which might reduce apothecium formation or longevity; reduced humidity surrounding leaves, which could retard mycelial growth from ascospore lesions (5); and a temporary reduction in canopy height, which might affect disease spread later in the winter. Counts of apothecia were not made in this study to avoid disturbance to plots and spread of ascospores.

January clipping treatments gave highly variable effects on disease severity and clover yields. In 1988, the January clipping main effect on yield and disease severity in high-intensity plots was statistically highly significant and positive. Disease severity was greatly reduced and clover yields were greatly increased over unclipped plots, especially in plots that received combined November and January clippings. In 1987, however, the January clipping main effect was not statistically significant, and in 1985 this treatment caused great reductions in yield when followed by a succession of hard freezes. These results suggest that January clipping may give significant control of SCSR, especially when preceded by November clipping, but it should not be attempted in latitudes or environments where severe freezes are likely. When beneficial effects result from January clipping, the most likely explanation appears to be that foliage with leaf lesions caused by ascospore infection is removed before secondary disease development. Positive responses might also result from aeration, drying, and reduction of the canopy, which could limit secondary disease spread.

Although data for February clipping is limited, there is no evidence from this study to suggest that it may be useful for cultural control of SCSR in crimson clover at Mississippi State. Disease severity was reduced by February clipping in the drought year of 1986, but not in 1987 when environmental conditions favored SCSR. Furthermore, February clipping significantly reduced yields in both years. These results may be especially relevant for those who may consider recommending clipping for disease control after rotting symptoms of SCSR become evident.

Further studies are needed to evaluate the applicability of these results for cultural control of diseases caused by *S. trifoliorum* at other locations and in other fall-planted forage legumes in the southeastern United States.

ACKNOWLEDGMENTS

I thank Deborah L. Boykin, USDA-ARS, area statistician, Stoneville, MS, for performing statistical analyses and assisting in their interpretation, and M. S. Stokes for technical assistance.

LITERATURE CITED

1. Dillon Western, W. A. R., Loveless, A. R., and Taylor, R. E. 1946. Clover rot. J. Agric. Sci. 36:18-28.
2. Dunivan, L. S. 1982. Vetch and clover overseeded on a bahiagrass sod. Agron. J. 74:793-796.
3. Graham, J. H., Frosheiser, F. I., Stuteville, D. L., and Erwin, D. C. 1979. A Compendium of Alfalfa Diseases. American Phytopathological Society, St. Paul, MN. 65 pp.
4. Knight, W. E., and Hollowell, E. A. 1959. The effect of stand density on physiological and morphological characteristics of crimson clover. Agron. J. 51:73-76.

5. Loveless, A. R. 1951. Observations on the biology of clover rot. Ann. Appl. Biol. 38:642-664.
6. Nilsson-Leissner, G., and Sylvén, N. 1929. Studies on clover rot (*Sclerotinia trifoliorum*). Sver. Utsäedesföeren. Tidskr. 39:130-158.
7. Pape, H. 1937. Beiträge zur biologie und bekämpfung des Kleekrebses (*Sclerotinia trifoliorum* Erikss.). Arb. Biol. Reichsanst. Land Forstwirtsch. Berlin-Dahlem 22:159-247
8. Pratt, R. G. 1988. Influence of foliar clipping treatments on pathogenesis of crimson clover by *Sclerotinia trifoliorum*. (Abstr.) Phytopathology 78:1580.
9. Pratt, R. G., Dabney, S. M., and Mays, D. A. 1988. New forage legume hosts of *Sclerotinia trifoliorum* and *S. sclerotiorum* in the Southeastern United States. Plant Dis. 72:593-596.
10. Pratt, R. G., and Knight, W. E. 1982. Formation of apothecia by sclerotia of *Sclerotinia trifoliorum* and infection of crimson clover in the field. Plant Dis. 66:1021-1023.
11. Pratt, R. G., and Knight, W. E. 1984. Comparative responses of selected cultivars of four annual clover species to *Sclerotinia trifoliorum* at different inoculum levels in the field. Plant Dis. 68:131-134.
12. SAS Institute, Inc. 1982. SAS User's Guide: Statistics. SAS Institute, Inc., Cary, NC. 584 pp.
13. Scott, S. W. 1984. Clover rot. Bot. Rev. 50:491-504.
14. Valleau, W. D., Fergus, E. N., and Henson, L. 1933. Resistance of red clover to *Sclerotinia trifoliorum* Erik. and infection studies. Ky. Agric. Exp. Stn. Bull. 341:115-131.
15. Wadham, S. M. 1925. Observations on clover rot (*Sclerotinia trifoliorum* Eriks.). New Phytol. 24:50-56.
16. Welty, R. E., and Busbice, T. H. 1978. Field tolerance in alfalfa to Sclerotinia crown and stem rot. Crop Sci. 18:508-509.
17. Welty, R. E., and Rawlings, J. O. 1984. Effect of benomyl on Sclerotinia crown and stem rot of alfalfa. Plant Dis. 68:294-296.
18. Williams, G. H., and Western, J. H. 1965. The biology of *Sclerotinia trifoliorum* Erikss. and other species of sclerotius-forming fungi. II. The survival of sclerotia in soil. Ann. Appl. Biol. 56:261-268.