SCLEROTINIA IN ALFALFA : BIOLOGY AND CONTROL IN THE CENTRAL VALLEY

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ABSTRACT

Sclerotinia stem and crown rot of alfalfa can be a significant disease in California's Central Valley in wet and/or foggy winters. Previous studies have failed to demonstrate significant control with cultural and weed control measures. Planting in September has numerous advantages in terms of stand establishment, seedling survival, and subsequent yields compared to the more traditional planting times of November through February. However, in years conducive to Sclerotinia crown and stem rot, growers feel the advantages of early seeding are negated by stand loss due to this disease. No fungicides are currently registered for controlling this disease in California. Because moisture and humidity favor disease, one management strategy has been to minimize canopy by burning back plant and weed growth with paraquat (Gramoxone Max). Two trials in the winter of 2004/2005 evaluated unregistered fungicides in addition to cultural and weed control measures. The fungicides Pristine (boscalid + pyraclostrobin) and Endura (boscalid) reduced disease ratings and increased yields in the first cutting compared to untreated controls, early mowing, and paraquat application.

Key Words: Sclerotinia, white mold, Pristine Endura, Gramoxone, foliar nutrients

INTRODUCTION

Stem and crown rot of alfalfa caused by the fungus *Sclerotinia* occurs worldwide in temperate growing regions. Two species, *S. sclerotiorum* and *S. trifoliorum*, can cause this disease. For several years it was assumed that *S. sclerotiorum* was the species in California infecting alfalfa but in the last few years a sample was confirmed as *S. trifoliorum*. It is likely that both species are present and practically speaking it probably does not matter which species is involved because both cause similar symptoms and require similar environmental conditions for disease development.

Both seedlings and established alfalfa can be infected. The most obvious symptom is wilting or flagging of stems. When examined, infected stems usually have a light tan to bleached area somewhere between the base of the stem and the stem tip. It is usually soft and at times "mushy." Any plant tissue at the distal portion of the stem, which is on the tip side of the infected area, will wilt and die. Leaves usually remain attached to the stem When conditions are favorable (cool and moist) white strands (mycelium) of the fungus are visible on stems and around the base of infected plants. From this sign of the fungus the disease gets its informal

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name of “white mold.” In advanced cases when the host food source has been consumed or the weather turns warm and dry, small black resistant structures (sclerotia) of the fungus form in infected stems or at the base of plants.

Usually only stems are killed and the crown survives when established plants are infected. However, if conditions for disease remain favorable for a long time or if plants are already weakened prior to infection, established plants may die. Seedlings are more likely to be killed as crowns have not yet been formed or, if formed, are much smaller than in established plants.

There are many advantages to planting alfalfa in September and early October in the Central Valley. Seeds germinate and seedlings emerge in less than one week. At this time, summer weeds are less competitive and winter weeds have not yet begun germinating. Later, when weeds are more competitive, the alfalfa already has a head start. In addition, if herbicide application is necessary the crop is large enough to spray with any of the herbicides registered on seedling alfalfa. Another advantage to early planting is the yield bonus in the first year of production compared to spring plantings. In some trials, this yield advantage continued into the second year of production.

The one disadvantage to planting alfalfa in late summer/early fall, is the potential to get Sclerotinia stem and crown rot. While early planted alfalfa will usually have developed crowns by the time Sclerotinia appears in the field, making them more likely to survive infection, the dense canopy of early planted fields contributes to high moisture and maintenance of favorable conditions for disease development increasing the chance that seedlings could be killed. Because there have been no really effective control measures for Sclerotinia in alfalfa, some growers who used to plant in September are now delaying until November or later in order to avoid this disease.

BIOLOGY

Life Cycle of Sclerotinia The fungus survives unfavorable conditions such has high temperatures, low humidity, or lack of a food source, as a hard black structure called a sclerotium (plural: sclerotia). These range in size from 0.03-0.31 inches in diameter and look like small dark pebbles. If formed inside an infected stem, they are cylindrical in shape. If formed at the base of an infected plant, they are “roundish” but irregular in shape. They can survive in the soil and on the soil surface. In some studies, they have survived over 5 years. There are also reports that some sclerotia survived the digestive tract of sheep.

When conditions are favorable, sclerotia may germinate as mycelium (strands of the fungus), which can infect plants directly. However, more commonly, sclerotia germinate to produce a spore forming fruiting structure called an apothecium (plural: apothecia). Apothecia are small (0.1-0.4 in diameter), orange-brown in color, and found on the soil surface. They contain thousands of spores (ascospores) that are forcibly ejected into the surrounding air currents. It is unknown just how far the spores can travel. If apothecia form under a canopy, most spores will stay in the field. If there is no canopy, the light spores may be able to travel to adjacent fields, and perhaps even farther.

Spores germinate when they land on a susceptible plant and environmental conditions are favorable for infection (cool and moist). As the fungus grows through the host, plant tissues die. Eventually either conditions become unfavorable or the food source runs out. At this point, the fungus starts to make sclerotia, completing the cycle.

Disease cycle of Sclerotinia Stem and Crown Rot In the case of alfalfa in California's Central Valley, favorable conditions for sclerotia to germinate and produce apothecia usually occurs in late fall/early winter when soil temperatures have dropped and soil moisture is sufficient due to rain or irrigation. Spores are ejected and if conditions are moist enough from rain, dew, or fog, they will germinate and infect host plants. The source of spores for an alfalfa field can be from within the same field or from an adjacent field. Both *S. sclerotiorum* and *S. trifoliorum* have broad host ranges including many weeds in addition to alfalfa. As long as conditions remain moist, the fungus will continue to spread in the infected plant. It can also spread to other stems in contact with infected plant tissue or to adjacent crowns. Sclerotia form whenever the host tissue is consumed or if the weather turns dry. Most of these sclerotia will fall to the ground to produce apothecia in the following fall when conditions are again favorable.

CONTROL/DISEASE MANAGEMENT

In seedling fields, delaying planting until late January/early February minimizes the risk of disease because by the time seedlings emerge there is less likely to be prolonged periods of rain or fog.

Because high humidity is critical for disease development, several strategies to minimize humidity in the canopy may be helpful, especially in years when conditions conducive for disease are borderline. However in a winter during which rain or fog maintain high humidity for long periods of time, these methods won't be helpful. A late fall harvest in established fields reduces canopy in the winter months. There are anecdotal observations where rain interrupted a late green chop harvest and resulted in little disease in the harvested portion of the field and lots of disease in the uncut portion of the field. Weed control in either established or seedling fields will reduce the canopy density and may help the field to dry out quicker after a rain or fog episode.

Crop rotation may help but because of the wide host range and the fact that spores can come from nearby fields, this practice is not always successful. A crop that is not a host has to be grown and winter weeds must be controlled. Garbanzos, carrots, and cauliflower are some susceptible winter crop hosts. Common winter weed hosts include Shepherd's purse, London rocket, vetches, and annual sowthistle.

Deep plowing, especially if soil is inverted, is recommended when coming out a field that had Sclerotinia. The deeper sclerotia are buried the less likely apothecia will form on the soil surface. However, remember that spores can be airborne from adjacent fields.

Biological control may help in the future as there are at least 30 species of fungi, and bacteria and insects reported to parasitize or antagonize *Sclerotinia* sclerotia. A few have been studied but to date there hasn't been a product that has demonstrated control of Sclerotinia in alfalfa under California conditions.

Genetic resistance is the ideal solution but to date no commercial varieties in our area claim to have resistance to this disease. Varieties that are more dormant may have less disease because they have less canopy in winter; however, choosing to plant a very dormant variety just to avoid this disease in case it is a wet winter does not make good economic sense because of the reduced yields with more dormant varieties.

Chemical control methods have been limited to the use of herbicides to reduce weeds in order to open up the canopy and reduce humidity . Paraquat has been the most commonly used herbicide for this purpose because it also burns back alfalfa growth, opening up the canopy even more. Trial work in the Central Valley has concentrated on seedling fields because they are most at risk for the disease to actually kill plants. An article in the proceedings from the 1997 California Alfalfa Symposium describes a trial in a September planted field. In addition to an untreated control, treatments applied in January included mowing, mowing plus a paraquat application, and paraquat alone. There were no significant differences in disease estimates or yield although there was a trend for the untreated control to have the highest level of disease and the highest yields. This is because paraquat and mowing burnt back and removed growth prior to harvest thereby reducing yields. In addition weeds were not controlled in the untreated plots, increasing yields. It was unclear if paraquat succeeded in reducing disease but at least Sclerotinia was no worse in paraquat treated plots.

There are no effective fungicides registered on alfalfa in California for control of this disease. At one point in time there had been a fungicide registered in other states but alfalfa was removed from the label some time ago. Recently newer fungicides have been registered in other crops for controlling Sclerotinia-caused diseases. Endura and Pristine were evaluated in two trials in California in the winter of 2004/2005. Endura contains the active ingredient boscalid (0.7 oz a.i./oz). Pristine contains boscalid (0.252 oz a.i./oz) and a second active ingredient, pyraclostrobin (0.128 oz a.i./oz).

2004/2005 TRIALS

Conditions were very favorable for Sclerotinia stem and crown rot in the winter of 2004/2005. Significant rains in November followed by continued wet or foggy conditions through January and into February provided environmental conditions for this disease to thrive. Materials tested included Gramoxone Max (paraquat), Pristine, and Endura. In addition two foliar fertilizers were included in the second trial. The foliar fertilizers were: Formula 1, a 0-29-26 phosphyte material, and Protect Ag, which contains sulfur, manganese, and zinc. Both of these fertilizers are produced by Custom Agricultural Formulators out of Fresno. In both trials, there was some disease already in the plots when treatments were applied. Applications were applied with backpack sprayers and non-ionic surfactants were used with Pristine and Endura in both trials. Plots were harvested with small plot harvesters and moisture samples were taken to calculate the dry matter production for each plot.

In Trial 1 (Table 1), seedling alfalfa planted in Yolo Co. on Nov. 5, 2004, was treated with Pristine @ 22 oz/A, Gramoxone Max @ 8 fl. oz./A, or left untreated on January 25, 2005, in a randomized complete block design with 4 replications. Seedlings were about 2.5 inches tall at the time of treatment. Three hours after treatment it started raining and half an inch fell in the next 24 hours. Two days later all treatments were oversprayed by air with 8 fl oz/A of Gramoxone Max.

When harvested on April 20, 2005, the treatment with Pristine+Gramoxone Max produced significantly more than either rate of Gramoxone alone. Yield data was also collected from three replications at the second and sixth cuttings. Although not statistically significant at the 5% level, there was a trend for the treatment with Pristine to yield higher at those cuttings than the treatments without Pristine. Plant stand counts, based on 1 sq ft per plot, taken after the sixth cutting indicated that there were significantly more plants/sq.ft. in the Pristine plots than in the other plots.

Trial 2 (Table 2) was conducted on Tulare Co. field planted in mid-September. There were 3 replications of a randomized complete block design with split-split plots. Main blocks were either left unmowed or were mowed on December 3, 2004. At this time the alfalfa was 8 to 10 inches in height. Six split-plot treatments were applied on December 10, 2004. These included Gramoxone Max, a mix of the foliar fertilizers (Formula 1 and Protect Ag), Gramoxone Max plus the two foliar fertilizers, Endura, and Pristine. The 11 oz rate of Endura contained 7.7 oz boscalid/acre and the 18.5 oz/A rate of Pristine contained 4.7 oz/A boscalid and 2.4 oz/A of pyraclostrobin. Because conditions were so favorable for disease through January, a final split plot application of Endura was applied to one half of all plots on January 25, 2005. Disease was evaluated using a 0-10 subjective scale with 0 = no disease and 10 = the entire plot infected. After the second harvest, skips in the drill rows were measured to estimate the impact of disease on stand.

About 1 month (January 5, 2005) after the first sprays, disease ratings were taken (Table 2). There was less disease in mowed plots than in unmowed plots. Of the split plots, the Pristine treatment had significantly less disease than all other treatments. The Gramoxone treatments and the Endura treatments had intermediate levels of disease. The untreated and the foliar nutrients without Gramoxone had the highest disease ratings. There was a significant interaction (P=0.04) between mowing and spray applications (Figure 1) in which most treatments had less disease when mowed but the Gramoxone treatment had about the same level of disease with or without mowing. By the disease rating on Feb. 25, disease levels were reduced overall compared o the early January rating. The effect of mowing was no longer significant and the Endura treatment had less disease than all other treatments. The January 18th overspray of Endura on half of each plot reduced disease compared to not overspraying.

At the first cutting in April, split plots treated with Pristine or Endura in December yielded more than all other treatments. There was a significant interaction between mowing and split plots showing that not all treatments responded in the same way to mowing. (Figure 2). The second application of Endura increased yields by 0.14 tons/acre compared to plots that were not sprayed.

At the second cutting in May, there were no differences among the split plot treatments. However, the January overspray with Endura produced almost 0.2 tons/acre more than plots not sprayed and this difference was statistically significant.

Pristine and Endura treatments had a higher percentage or remaining stand than the other treatments when evaluated after the second harvest (Table 2). Treatments with Gramoxone Max by itself or with foliar nutrients were intermediate in stand impacts. The overspray of Endura in Janaury increased stand counts. Due to problems with a leaky valve, the area of the field where the plot was located became rutted by equipment and unfortunately no further yield data was collected.

SUMMARY

Results from these trials indicate that Endura or Pristine could be helpful tools for managing Sclerotinia on seedling stands planted in September or later. BASF, which markets both fungicides, is interested in further studies with Pristine. Additional research will also provide more information on timing, rates, long term benefits and the economics of fungicide treatment.

REFERENCES

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TABLES

Table 1. Yield data from Trial 1, Yolo County.[1]

Treatment	Rate/A	Date Applied	Alfalfa Yield First Cutting Tons/A	Alfalfa Yield Second Cutting Tons/A	Alfalfa Yield Sixth Cutting Tons/A	Plants/sq. ft following Sixth Cutting
Gramoxone Max	8 fl oz	Jan. 25	0.72 b	1.10	0.62	7.9 b
Gramoxone Max	16 fl oz	Jan. 25	0.81 b	1.22	0.58	7.6 b
Pristine and Gramoxone Max	22 oz + 8 fl oz	Jan. 25	1.00 a	1.37	0.75	10.83 a
Probability			.025	.064	.144	.038

[1]Values within a column do not differ at the 5% level using LSD.

Table 2. Yield data from Trial 2, Tulare County[1].

Treatment	Rate per Acre	Date Applied	Disease Rating Jan. 5	Disease Rating Feb 25	Tons/Acre April 19	Tons/Acre May 20	Percent Stand Remaining May 26
Unmowed	--	--	5.3	2.3	2.56	2.42	56.93
Mowed	--	12/03/04	4.1	1.7	2.42	2.30	50.20
Probability			*0.01*	*0.17*	*0.08*	*0.31*	*0.12*
1. Untreated Control	--		6.3 d	2.2 b	2.43 bc	2.35	47.53 bc
2. Gramoxone Max	21.3 fl oz	12/10/2004	4.8 c	2.3 b	2.22 c	2.34	55.94 ab
3. Formula I and Protect Ag	1 qt 1 qt	12/10/04	5.8 d	2.3 b	2.55 b	2.34	41.22 c
4. Gramoxone Max Formula I and Protect Ag	21.3 fl oz 1 qt 1 qt	12/10/04	4.3 bc	2.6 b	2.24 c	2.29	56.50 ab
5. Endura	11 oz	12/10/04	3.8 b	0.8 a	2.72 a	2.40	58.55 a
6. Pristine	18.5 oz	12/10/04	2.8 a	1.8 b	2.78 a	2.46	61.65 a
Probability			*0.00*	*0.01*	*0.00*	*0.18*	*0.00*
No second spray	--	--	--	2.6	2.40	2.28	49.11
Endura Spray	11 oz	1/18/2005	--	1.3	2.54	2.44	58.02
Probability			--	*.001*	*.00*	*.00*	*.00*

[1]Values within a column followed by a common letter do not differ significantly using LSD

Figure 1. Disease ratings from Trial 2 showing interaction of mowing with treatments meaning not all treatments responded to mowing in the same way.

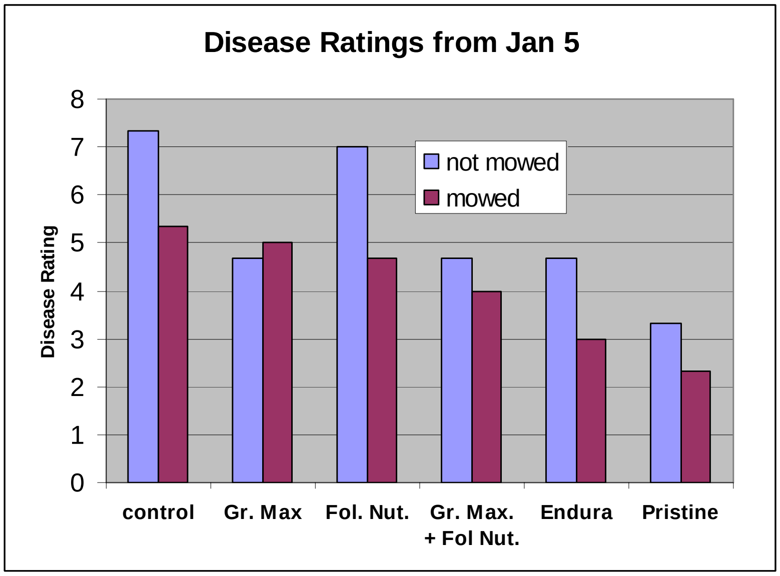

Figure 2. Yields from Trial 2 showing interaction of mowing with treatments.