W 995

Hemp Fungicide Efficacy Field Trial for Leaf Spot and Powdery Mildew

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Introduction

Hemp production has increased dramatically in Tennessee in recent years, and several diseases of hemp have been observed. A summary of hemp production in Tennessee is available in the University of Tennessee Extension publication "W 777 Status of Industrial Hemp in Tennessee." Hemp leaf spot, which has been associated primarily with *Curvularia* sp. and *Bipolaris* sp. in Tennessee, and powdery mildew, which is caused by *Golovinomyces* sp., are among the hemp diseases most frequently reported. An overview of hemp pests and diseases in Tennessee can be found in the University of Tennessee Extension publication "W 916 Hemp Disease and Pest Management." The present publication publication is a report of an experimental trial that was performed to test the efficacy of four fungicide products for managing hemp leaf spot and powdery mildew diseases in Tennessee.

Hemp leaf spot and powdery mildew symptoms

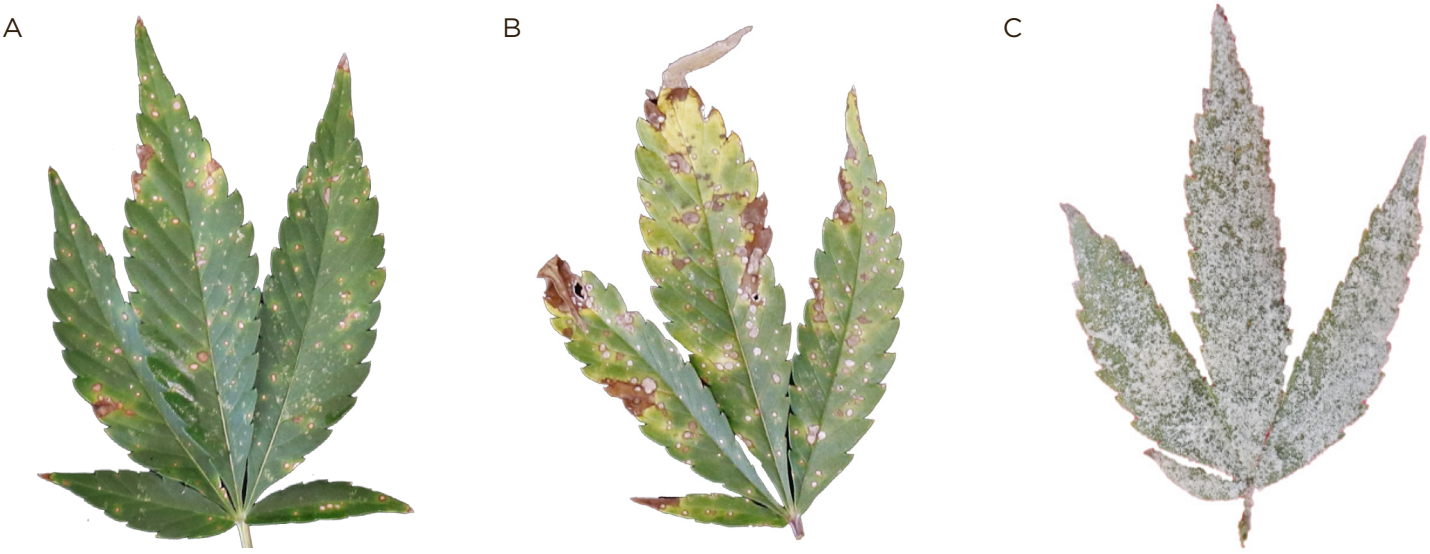

Figure 1. Symptoms of hemp leaf spot and powdery mildew. (A) Hemp leaf spot showing small circular lesions with a tan center and brown margin. (B) Leaf spot with multiple coalesced lesions and leaf yellowing. (C) Hemp powdery mildew on the upper surface of a hemp leaf. The white powdery substance is a mass of fungal mycelium and asexual spores (conidia).

Hemp leaf spot starts as small circular lesions with a tan center and brown margins. As the disease progresses, it can develop into large irregular-shaped lesions with dark centers and brown/purple margins (Figure 1A), and multiple lesions may merge (coalesce) to cause leaf blight, which may cause the leaf to turn yellow and fall off prematurely (Figure 1B). Additional information on hemp leaf spot signs and symptoms can be found in the publication "W 916 Hemp Disease and Pest Management."

Hemp powdery mildew is a foliar disease that appears on the upper leaf surface as a white powdery substance (Figure 1C). The white powder is made up of fungal mycelium and asexual spores (conidia). The mycelium grows into the leaf and deprives the leaf of nutrients and water, resulting in symptoms such as leaf distortion, necrosis and premature defoliation. Powdery mildew symptoms are often observed in hemp grown in greenhouses and high tunnels when temperatures are moderate (70-80 degrees F) and high humidity which favors the disease. The disease also occurs in the field but is often less severe. In a conducive environment, powdery mildew can produce large numbers of infective spores that are spread easily within and between fields. Winds, greenhouse fans and mechanical means can help to spread the spores to non-infected plants to cause new infections. A newly infected plant will become a source of spores between 5 to 10 days after infection and spread the disease to healthy plants to repeat the disease cycle. Additional information on hemp powdery mildew signs and symptoms can be found in the publication "W 916 Hemp Disease and Pest Management." The following publications contain additional information on hemp powdery mildew:

- Management of Powdery Mildew Begins with Understanding the Causal Fungus
- Control of Powdery Mildew and Cercospora Leaf Spot on Bigleaf Hydrangea with Heritage and Milstop Fungicides

Materials and experiment procedures

Fungicides and hemp cultivar: Four fungicide products were tested: Stargus (Marrone Bio Innovations, Davis, California), Defguard (General Hydroponics, Sebastopol, California), Exile (General Hydroponics, Sebastopol, California), and Regalia (Marrone Bio Innovations, Davis, California). The field trial was performed using the 'T1' hemp cultivar (South Central Growers, Springfield, Tennessee), which is known to be susceptible to leaf spot and powdery mildew. More information on hemp varietal disease susceptibility can be found in the Extension publication "W 900 Hemp Variety Trials in Tennessee, 2019," and in the Extension publication "W 916 Hemp Disease and Pest Management." Stargus is a biological fungicide containing *Bacillus amyloliquefaciens* F727 as the active ingredient (AI). Defguard is a biological fungicide containing *Bacillus amyloliquefaciens* D747 as the AI. Exile contains potassium salts of fatty acids as the AI, and Regalia contains extract of Giant knotweed (*Reynoutria sachalinensis*) as AI. All four fungicides are approved for organic use (OMRI listed) and are labeled for use on hemp in Tennessee.

Experiment location, design and management: The experiment was conducted at the University of Tennessee Northeast Tennessee AgResearch and Education Center in Greeneville, Tennessee, between July 13 and October 19, 2020. Eight seedlings of 'T1' were transplanted per two-row plot. There were 2 feet between plants within rows and 6-foot centers between rows. The plots were organized in a randomized complete block design with four replicates. After transplanting, the plots were irrigated by hand watering two to three times per week as required and weeded by mechanical cultivation throughout the season. The plots were monitored weekly for disease development by natural infestations. Once leaf spot severity was about 2 percent, fungicide applications were commenced. The applications started on July 28 and repeated seven times at approximately 10-day intervals. The applications were made using an 11-liter CO_2 backpack sprayer system equipped with two Tee-Jet 800 2VS flat fan-nozzles at 40 psi. A thorough spray covering both sides of the plots (approximately 80 gal/acre) was achieved for each application. Application rates can be found in Table 1. All treatments were compared to untreated control plots. Disease ratings were taken on Sept. 28, Oct. 8, and Oct. 19. An average value of disease incidence and severity for each plot was recorded. The disease incidence was the percentage of leaves with disease symptoms, while severity was the average diseased area of the leaves showing at least one disease lesion.

Data analysis procedures and interpretations

Disease incidence and severity data were used to determine the disease index (DI), which summarizes both incidence and severity for each date. The DI was calculated by multiplying incidence (I) by severity (S), and divide by 100 (i.e., DI = (I*S)/100, where 100 represents the maximum possible incidence and severity scores). Thereafter, DI data were used to determine the overall disease intensity (AUDPC = Area Under the Disease Progress Curve) over the period of the experiment. The resulting data were analyzed using the Glimmix procedure in SAS (SAS Institute, 9.4, Cary, North Carolina), with fungicide treatment as a fixed effect, replicate as a random effect, and least-squares means separated using the Tukey test at P = 0.05. In other words, it is 95 percent likely that the statistically significant differences observed in this trial are due to treatment effects.

Growing season climate

During the trial, the total monthly rainfall recorded for July, August, September and October was approximately 3, 5, 5, and 8 inches, respectively. While the average day and night temperatures recorded for July, August, September and October were 89 F and 66 F, 85 F and 65 F, 78 F and 57 F, and 72 F and 47 F, respectively.

Results

Exile, Regalia and Stargus significantly reduced leaf spot disease compared to the untreated control (Table 1). Defguard did not reduce leaf spot compared to the untreated control. When compared to untreated plots, Exile reduced leaf spot by 44 percent, Stargus reduced leaf spot by 43 percent and Regalia reduced leaf spot by 41 percent, compared to the untreated control.

For the powdery mildew test, Defguard, Exile and Regalia significantly reduced hemp powdery mildew compared to the untreated control. Stargus did not significantly reduce powdery mildew. When compared to the untreated plots, Regalia and Exile reduced powdery mildew by 99 percent and 91 percent, respectively, and provided excellent control. Defguard moderately reduced powdery mildew by 52 percent when compared to untreated plots. Stargus did not significantly reduce powdery mildew compared to the untreated control.

Table 1. Hemp fungicide product efficacy for managing leaf spot and powdery mildew

	Leaf spot			Powdery mildew		
Treatment (Rate per acre)	Disease intensity*	Disease reduction (%)	Product efficacy	Disease intensity*	Disease reduction (%)	Product efficacy
Defguard (6 qt)	627a**	2	None	1357bc	52	Moderate
Exile (2% v/v)	357b	44	Moderate	264c	91	Excellent
Regalia (2 qt)	381b	41	Moderate	15c	99	Excellent
Stargus (4 qt)	368b	43	Moderate	2247ab	20	None/ low
Untreated	643a	-	-	2806a	-	-

*Disease intensity is represented by the area under the disease progress curve (AUDPC), which is a statistic that includes a disease index calculated at each disease rating date to represent the disease intensity over the course of the entire experiment or growing season.
**Numbers followed by the same letter(s) within columns are not significantly different (Tukey test, P<0.05).

Table 2. Fungicide product market price and estimated cost per acre treatment

Treatment (Rate per acre)	Avg. market price per qt ($)	Estimated cost per application per acre ($)	Estimated cost per 8 applications ($)
Defguard (6 qt)	37	222	1776
Exile (2% v/v; 4qt)	25	100	800
Regalia (2 qt)	49	98	784
Stargus (4 qt)	16	64	512

Conclusion

Exile, Stargus and Regalia exhibited moderate control of leaf spot. Regalia and Exile exhibited excellent control of powdery mildew, while Defguard exhibited moderate control of powdery mildew. It is important to note that fungicide sprays began when disease severity was low and was repeated at approximately 10-day intervals. Therefore, these results reflect the protectant activity of the products discussed. It is unknown how these products would perform as a curative treatment applied after significant disease has developed. These results should be considered preliminary, as the trial has not yet been repeated. However, these products exhibited promising potential to be used as fungicide control options by hemp growers to control hemp leaf spot and powdery mildew in Tennessee. Table 2 shows the market price and estimated cost of using each product per acre. This information will further assist growers to determine which of the products will be most economical.

Additional resources

Gauthier, N. (2020). Management of Powdery Mildew Begins with Understanding the Causal Fungus. The University of Kentucky Extension. Retrieved from http://www.kyhempdisease.com/powdery-mildew-of-hemp.html

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Walker, E. (2018). Status of Industrial Hemp in Tennessee. University of Tennessee Extension. Retrieved from https://www.tn.gov/content/dam/tn/agriculture/documents/planthealth/StatusOfIndustrialHempinTN_102218_W777.pdf

Precautionary statement

To protect people and the environment, pesticides should be used safely. This is everyone's responsibility, especially the user. Read and follow label directions carefully before you buy, mix, apply, store or dispose of a pesticide. According to laws regulating pesticides, they must be used only as directed by the label.

Disclaimer

This publication contains pesticide recommendations that are subject to change at any time. The recommendations in this publication are provided only as a guide. It is always the pesticide applicator's responsibility, by law, to read and follow all current label directions for the specific pesticide being used. The label always takes precedence over the recommendations found in this publication.

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