

Final Technical Report

Grant 24*3024 Assessment of plant varieties and disease management to improve hop and barley quality

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Abstract

Michigan ranks fourth in hop production with about 720 acres grown in the state while Michigan's barley industry is worth \$1.8 million annually. The most economically important late season barley disease is Fusarium head blight that can introduce a mycotoxin in beer. Hops are affected by late season cone blights, such as downy mildew and a recently discovered disease known as halo blight. These diseases of hop induce cone shatter, alter hop aromas, and can cause over 50% yield loss. This proposal's focus is on late season diseases and maximizing crop quality of barley and hops for both Michigan industries.

Goals and Objectives

Due to humid growing conditions in the spring and summer, fungal diseases can be an issue in barley and hops. Fungicide use is encouraged as it may reduce the severity of FHB by 20 to 50% and DON levels by 40 to 60%, although the actual reductions are highly variable. It is poorly understood in Michigan which products are most effective at DON management. Furthermore, fungicides tend to boost yields in barley, but limited research is available for the humid wet Michigan growing conditions (Nagelkirk, 2016). This proposal will assess barley cultivar's response to disease and subsequent development of DON and will also investigate management practices. As fungicides are costly and are not overly effective on halo blight, Michigan growers need additional control methods. This proposal will investigate cultivars for disease resistance and evaluate the effect of system fungicides on halo blight development.

Objective 1) A meta-analysis to determine the optimal fungicide program for head blight of barley.

Objective 2) Screen commercial hop varieties for resistance to downy mildew and halo blight.

Objective 3) Evaluate the effect of systemic fungicides on downy mildew and halo blight of hops.

Objective 4) Update extension materials for Michigan hop and barley farmers with findings from research.

Brief Literature Review

Barley and wheat disease management is critical, not only to protect yield, but also quality. Fusarium head blight (FHB) is a major concern with respect to the production of mycotoxins such as deoxynivalenol (DON). Our 2020 and 2021 fungicide efficacy trials demonstrated that when the appropriate product was applied at the optimal time it was possible to potentially reduce the DON contamination by 50% (Chilvers et al., 2020). In addition to FHB, barley and wheat are susceptible to several foliar diseases such as rusts, powdery mildew, and scald (Murray et al., 2011). It is essential to correctly identify diseases to ensure that correct management practices are used. There are differences in epidemiology, fungicide efficacies and management strategies between different fungal diseases (Murray et al., 2011). Not only do we see improved grain quality with appropriate selection of cultivars and an optimally selected and timed foliar fungicide, but yield is often much greater as well (Fig. 3). Barley disease management is understudied in Michigan and the U.S. In this project, we propose to develop production guidelines to optimize barley disease management in Michigan.

Hop cone diseases threaten production and can lead to significant issues with yield due to shatter, market access, and cone quality. Halo blight fungicide efficacy field trials were conducted at the Michigan State Plant Pathology Research Farm in 2020 and 2021. In this trial, fungicides registered for hops were tested for efficacy and application timing. Preliminary results showed that fungicide products in FRAC 3, 7, and 11 can reduce the incidence and severity of halo blight. Based on this data we conducted a trial in 2022 with several FRAC 3, 7, and 11 products that were most effective (Fig. 4). Presidio (FRAC 43) was applied in the beginning of the season to control downy mildew. Flint Extra (FRAC 11), Rhyme (FRAC 3) and LifeGard (an organic *Bacillus* product) resulted in the lowest incidence of halo blight.

Within this proposal, we will continue to improve IPM programs for both crops to support Michigan's growing craft beer industry. This proposal will also allow MSU Extension to optimize our communication strategies towards growers and present the best cultural, biological, and chemical control strategies in barley fields and hopyards.

Results, Conclusions, and Outcomes

- We found that Tahoma, Yakima Gold, Olympic, and Sterling are among the most susceptible to halo blight, while Comet, Sorachi Ace, Liberty, Cascade, and Chinook appear to have some resistance (Fig. 1).

- The drench trial did not show any differences in downy mildew or halo blight control from one or three drench applications (Fig. 2).
- However, Rhyme was more effective at controlling halo blight than Ridomil (Fig. 2).
- We have demonstrated that under low disease conditions foliar fungicides have minimal impact on barley grain quality parameters.

- We confirmed that the optimal fungicide timing for head scab and DON mycotoxin management in barley was 4-6 days post head emergence.
- In barley and wheat, we demonstrated that newer products labelled for head scab management are efficacious in suppressing head scab and DON levels.
- MSU extension materials were updated to reflect the findings of this project, such as the Michigan Hop Management Guide.
- Results from this work was presented at multiple extension meetings throughout the grant period, such as the Great Lakes Expo, the Michigan Great Beer State Conference, and the MSU Extension Field Crops Virtual Breakfast.

Time Span

February 2024 – August 2025

Work Accomplished/Methods

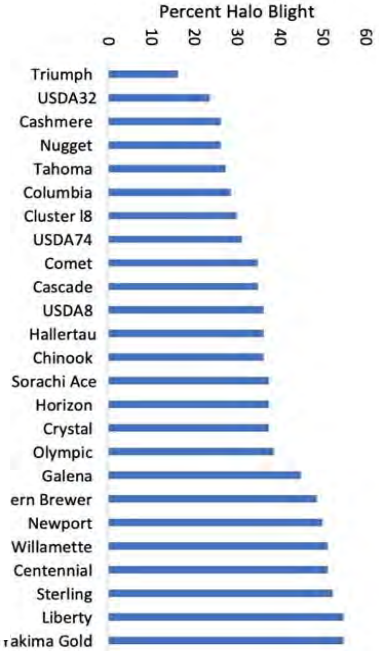


Fig. 1. Percentage of halo blight on whole plant rating of elite hop varieties.

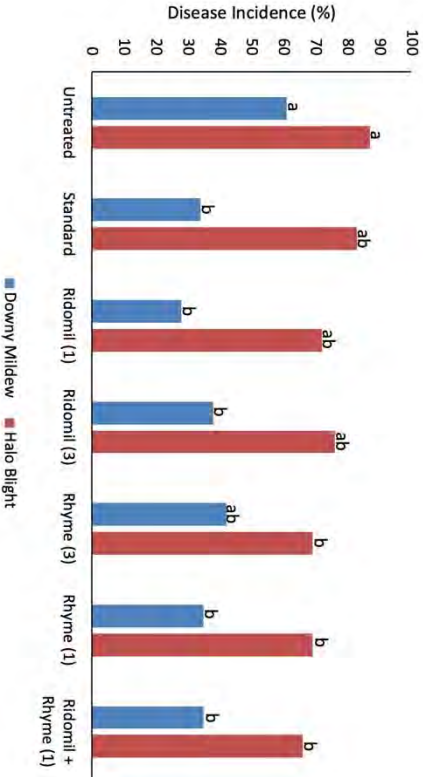


Fig. 2. Downy mildew and halo blight incidence resulting from drench trial. Treatments on x axis indicate the number of drench applications, either one or three.

No significant changes were made to the methods as described in the proposal.

Communication Activities, Accomplishments, and Impacts

Publications:

Submitted

1. Cinderella, J., Emanuel, I.B., McCoy, A.G., **Chilvers M.I.**, Anderson, K., Bergstrom, G.C., Bockus, W.W., Bradley, C.A., Breunig, M., Byamukama, E., Cowger, C., Faske, T.R., Friskop, A.J., Kelly, J., Kleczewski, N.M., Mideros, S., Noller, J., Paul, P.A., Price, T., Rawat, N., Shim, S., Stevens, J., Telenko, D., Betts, A.K. *Submitted Sep 17, 2024. Resubmitted May 30, 2025.* Establishment of baseline sensitivity levels of *Fusarium graminearum* from wheat grown in the United States to pydiflumetofen fungicide. Plant Disease
2. Breunig, M., Byrne, A.M., Jacobs, J.L., Ward, T.J., McCoy, A.G., and **Chilvers, M.I.** *Submitted June 12, 2024, resubmitted June 16, 2025.* Characterization of *Fusarium* species composition, chemotype, in planta and in vitro fungicide sensitivity of isolates from wheat and corn in Michigan, USA. Phytopathology

Published

3. Ortmeier-Clarke, H., Mourtzinis, S., Smith, D., **Chilvers, M.**, Telenko, D., Conley, S.P. 2025 Variety choice influences soft red winter wheat yield more than seed treatment. Crop, Forage and Turfgrass Management 11:e70037
<https://doi.org/10.1002/cft2.70037>
4. Friskop, A.J., Sisson, A.J., Allen, T.W., Anderson-Onofre, K.F., Aoun, M., Bergstrom, G.C., Bissonnette, K.M., Bowen, K.L., Bradley, C.A., Burrows, M.E., Byamukama, E., **Chilvers, M.I.**, Collins, A.A., Cowger, C., De Wolf, E.D., Dill-Macky, R., Esker, P.D., Faske, T.R., Hunger, R.M., Kelly, H.M., Kleczewski, N.M., Koehler, A.M., Langston, D.B., Marshall, J.M., Martinez-Espinoza, A.D., McKelvy, U., Mehl, H.L., Meyer, R.F., Obasa, K., Padgett, G.B., Paul, P.A., Price, P.P., Smith, D.L., Telenko, D.E.P., Tenuta, A.U., Wegulo, S.N., and Wiersma, J.J.. *Submitted Sept 5, 2024, Accepted Oct 21, 2024.* Wheat yield reduction and economic losses caused by disease from 2018 through 2021. Plant Health Progress
5. McCoy, A., Jacobs, J., **Chilvers, M.I.** 2024. Host range characterization of *Phytophthora sansomeana* across corn, soybean, wheat, winter cereal rye, dry bean and oats, and an in vitro assessment of seed treatment sensitivity. Plant Disease 108:2710-2721 <https://doi.org/10.1094/PDIS-11-23-2303-RE>
6. Hatlen, R. ††, Hausbeck, M., Anthony, M., Sysak, R., Smith, R., **Miles, T.** 2025. Chemical management strategies for halo blight of hops and in vitro fungicide sensitivity of *Diaporthe humulicola* populations to various fungicide classes. Plant Dis. 109, 638-645
7. Hatlen, R., Szymanski, S., Adair, N., Fan, Q., Panwar, P., Sysak, R., Miles, L., Higgins, D., Rojas, A., Gent, D., **Miles, T.** 2025. Development of a translation elongation factor 1-alpha (TEF) based TaqMan qPCR assay for *Diaporthe humulicola*, the causal agent of halo blight of hop. Plant Dis. First Look

Presentations:

Miles, T.D. Integrating microbial ecology, etiology, and resistance into the disease management of small fruit and hops. November 2024. Pennsylvania State University Departmental Seminar, State College, PA

Extension Publications:

1. Why all the fuss with the plant pathogen *Fusarium graminearum*? Wheat Wisdom. June 18, 2025
2. Scab risk elevated in some parts of Michigan. Wheat Wisdom. June 18, 2025
3. Fusarium risk prediction and disease update, and bioterrorism media buzz. Michigan Wheat News
4. Fusarium research under watch: How science and regulation work together to protect U.S. agriculture. MSUE News. May 6, 2025.
<https://www.canr.msu.edu/news/fusarium-graminearum-research-under-watch>
Picked up in Morning Ag Clips: <https://www.morningagclips.com/fusarium-how-science-and-regulation-protect-u-s-agriculture/>
5. Timely tips for managing wheat disease on May 8 Field Crops Virtual Breakfast. Celovesky and Chilvers. May 5, 2025 <https://www.canr.msu.edu/news/timely-tips-for-managing-wheat-disease-may-8-field-crops-virtual-breakfast>
6. Snow molds in cereal crops: What farmers need to know. Pennington and Chilvers. Michigan Wheat News. Apr 21, 2025
7. Anderson, N., Sisson, A., Turkington, K., Bowen, K., Faske, T., Meyer, R., Betts, A., Martinez Espinoza, A., Marshall, J., Camiletti, B., Telenko, D., Anderson-Onofre, K., Bradley, C., Price, P., Chilvers, M., Wiersma, J., Allen, T., Bish, M., McKelvy, U., Wegulo, S., Bergstrom, G., Cowger, C., Friskop, A., Paul, P., Aoun, M., Tenuta, A., Collins, A., Shires, M., Kelly, H., Obasa, K., Langston, D., Higgins, D., and Smith, D. 2025. Wheat Disease Loss Estimates from the United States and Canada – 2024. Crop Protection Network. CPN 3018-24.
<https://cropprotectionnetwork.org/publications/wheat-disease-loss-estimates-from-the-united-states-and-ontario-canada-2024>.
8. Wheat stripe rust outbreak and Fusarium head scab risk prediction. MSUE News. May 23, 2024 <https://www.canr.msu.edu/news/wheat-stripe-rust-outbreak-and-fusarium-head-scab-risk-prediction>
9. Managing wheat stripe rust outbreaks across the state. Michigan Wheat Program newsletter. May 20, 2024
10. Lizotte, E., Sirrine, R., **Miles, T.**, Chaudhari, S. 2024. 2024 Michigan Hop Management Guide. Available at:
https://www.canr.msu.edu/news/hop_management_guide_available_to_michigan_hop_growers
11. Lizotte, E., Sirrine, R., **Miles, T.**, 2024 Michigan Hop Management Guide now available. March 28, 2024.

https://www.canr.msu.edu/news/hop_management_guide_available_to_michigan_hop_growers

Extension Presentations:

1. Ed White, Associated Press, Detroit. Jul 2, 2025. Email correspondence regarding Fusarium smuggling case
2. Mark H. Stowers, Reporter, Downtown Publications / Lake Magazine. Email correspondence regarding Fusarium smuggling case
3. Simone McCarthy, Senior China Reporter | CNN International. Email correspondence regarding Fusarium smuggling case
4. Wheat field day. Wheat and barley disease management. Plant Pathology Farm. June 25, 2025. 100 participants
<https://www.youtube.com/watch?v=OA8neg5Z1o8>
5. Why Chinese carrying fusarium is a big deal. Farm Progress. Story by Tom J. Bechman. Midwest Crops Editor. <https://www.farmprogress.com/crop-disease/fusarium-smuggling-attempt-sparks-bioweapons-bill-highlights-ag-research-importance>
6. Chanel 7 WXYZ ABC Detroit. Interview with Darren Cunningham. Questions surround why a Chinese researcher allegedly lied about shipping harmless material. Jun 11, 2025. <https://share.google/O9cHPFTjJqpLoyjfc>
7. Fox 2 News. Interview with Ingrid Kelley. Jun 10, 2025. Chinese nationals investigation: MSU expert on alleged smuggled fungus
<https://www.fox2detroit.com/news/chinese-nationals-investigation-msu-expert-alleged-smuggled-fungus>
8. Brownfield News. Interview with Nicole Heslip. Jun 9, 2025
<https://www.brownfieldagnews.com/news/cool-wet-weather-impacting-michigans-crop-condition-somewhat/>
9. Michigan News Source. JP Isbell. *Fusarium graminearum* and University of Michigan. Jun 6, 2025 https://www.michigannewssource.com/2025/06/msu-professor-says-university-of-michigan-agroterrorism-theory-likely-overblown-in-u-m-fungus-case/?utm_source=in-article-related-1
10. Virtual Breakfast. Special Edition: Ag bioterrorism and wheat fungicides. Jun 5, 2025. 280 participants <https://www.canr.msu.edu/videos/ag-bioterrorism-and-wheat-fungicides>
11. *Fusarium graminearum* and University of Michigan. Jun 5, 2025. 280 participants
12. Brownfield News. Nicole Heslop. *Fusarium graminearum* and University of Michigan. Jun 5, 2025 <https://www.brownfieldagnews.com/news/fusarium-smuggling-case-spotlights-need-to-follow-research-protocols/>
13. ABC 7 News WXYZ-TV Detroit. Ross Jones. *Fusarium graminearum* and University of Michigan. Jun 5, 2025 <https://share.google/FQNjRAbrTWSwGXekY>
<https://www.wxyz.com/news/local-news/investigations/agroterrorism-espionage-or-research-questions-swirl-over-pathogen-smuggling-case>
14. Michigan Farm News. Dennis Rudat. Chinese researchers charged with smuggling potential 'agroterrorism weapon' into US.

<https://www.michiganfarmnews.com/chinese-researchers-charged-with-smuggling-potential-agroterrorism-weapon-into-us>

15. NPR News. Ayana Archie, James Doubek. *Fusarium graminearum* and University of Michigan. Jun 4, 2025
16. CBS News. Interview with Meredith Bruckner. *Fusarium graminearum* and University of Michigan. Jun 4, 2025
17. Detroit News. Interview with Carol Thompson. *Fusarium graminearum* and University of Michigan. Jun 4, 2025
18. Fortune Media. Paolo Confino. *Fusarium graminearum* and University of Michigan. Jun 4, 2025
19. Associated Press. Video interview with Mike Householder. *Fusarium graminearum* and University of Michigan. Jun 4, 2025
<https://www.yahoo.com/news/know-fungus-american-authorities-smuggled-192630047.html?guccounter=1>
20. Disease Management in Wheat and Small Grains – Virtual Breakfast. May 8, 2025, 200 participants <https://www.youtube.com/watch?v=xmhLE3eWaAQ>
21. Disease scouting. In service training. MSUE. Mason, MI. Mar 24, 2025. 20 people
22. Disease management. Simplot Customer Meeting. Owosso, MI Mar 4, 2025. 70 participants.
23. Fungicide options for field crops – Focus: Wheat. Star of the West Milling Co. Bad Axe. Feb 20, 2025 150 participants
24. Field crop disease management update. MSUE. Ithica, MI. Jan 15, 2025. 50 participants
25. Tar spot and disease management update. Simplot. Owosso, MI. Jan 15, 2025 100 participants
26. Field crop disease management update. MSUE. Bad Axe, MI. Jan 10, 2025. 80 participants
27. Disease management update. Michigan Agribusiness Association (MABA). Lansing, MI. January 7, 2025. 40 participants
28. Disease management update across wheat, corn, and soybean. Integrated crop and pest management update for agribusiness. MSUE, STEM teaching and learning facility, East Lansing, MI. 300 participants
29. Optimizing disease management. Dale Seyfred Farm, Galien, MI. Sep 10, 2024. 40 participants
30. Optimizing disease management. MSUE Centreville, MI. Aug 28, 2024. 20 participants
31. Optimizing disease management. Agro Expo, St Johns, MI. Aug 13, 2024. 50 participants
32. Beck Ag/FMC Disease Management Discussions. Virtual across. Corn, soybean and wheat disease. July 9, 2024. 98 participants
33. Wheat stripe rust, soybean white mold, tar spot of corn. Interview with Nicole Heslip with Brownfield News. July 3, 2024.
34. Beck Ag/FMC Disease Management Discussions. Virtual across. Corn, soybean and wheat disease. July 2, 2024. 117 participants

35. Beck Ag/FMC Disease Management Discussions. Virtual across Nebraska and Iowa. Corn, soybean and wheat disease. June 27, 2024. 54 participants
36. Wheat field day with discussion of corn tar spot and mycotoxin management. June 25, 2024. 150 participants
37. Crop Scouting Day. MSEU. Frankenmuth, MI. Jun 5, 2024. 14 participants.
38. Field Crop Disease Update and Disease Management Discussion. Golden Harvest. Jackson, MI. Mar 26, 2024
39. Field Crop Disease Update and Disease Management Discussion. Denny Corey Crop Shop. Corunna, MI. Mar 20, 2024. 50 participants.
40. USWBSI Webinar Wheat head scab. Mar 13. 147 participants
<https://www.youtube.com/watch?v=JYyv276NT8c>
41. Field Crop Disease Update and Disease Management Discussion. Jorgensen Mar 13. 100 participants
42. Hatlen, R., Lizotte, E., Sirrine, R., **Miles, T.** 2024. Managing Halo Blight of Hop. Available at: <https://www.canr.msu.edu/resources/managing-halo-blight-of-hop>

Budget Narrative

The project was conducted consistent with the budget proposed by the principal investigator and approved by the State of Michigan.



PhD student Fidel Jimenez Beitia spreading *Fusarium graminearum* inoculum in wheat and barley plots.



Spreading head scab inoculum for barley and wheat trials, Dr. Sunkyu Choi pictured collecting *Fusarium graminearum* inoculum, with barley and wheat trials in the background.



Barley and wheat plots under linear irrigation system at the MSU Agronomy farm, note plots have been trimmed to facilitate harvest



Head scab on wheat caused by *Fusarium graminearum* with linear irrigation system in background.



Wheat and barley planting, Dr. Martin Chilvers and Dr. Austin McCoy inspecting grain drill being operated by Micalah Herendeen and tractor driven by Bill Widdicombe



Experimental hop yard being irrigated to increase disease pressure at the MSU Plant Pathology Farm



Downy mildew early in the season at the MSU Plant Pathology Farm



Halo blight girdling a hop cone in the field