Washington Grain Commission
Wheat and Barley Research Annual Progress Report

Project #: 3144

Progress Report Year: 3 of 3 (2021)

Title: Improving Control of Rusts of Wheat and Barley

Cooperators: K. Garland Campbell, A. Carter, M. Pumphrey, & D. See

Executive summary: During 2021, studies were conducted according to the objectives of the project proposal, and all objectives specified for the third year were completed on time. In addition to the major accomplishments and their impacts listed below, this project results in genetic resources and techniques for further studying the biology and genetics of the pathogens, stripe rust resistance, and mechanisms of interactions between the pathogens and plants.

Impact: 1) Stripe rust was forecasted and monitored throughout the 2021 crop season, and rust updates and advises were provided on time to growers. In March, stripe rust was forecast at a low level and the disease occurred at the lowest level in the past 30 years. The recommendations prevented unnecessary use of fungicides, saving growers multimillion dollars. 2) We identified 18 races of the wheat stripe rust pathogen and 9 (including 1 new) races of the barley stripe rust pathogen from 301 samples throughout the U.S., of which 14 (78%) races of the wheat stripe rust pathogen and 6 (67%) races of the barley stripe rust pathogen were identified from 159 (53%) samples collected in Washington. The race information is useful in screening breeding lines and germplasm for developing stripe rust resistant varieties. 3) We completed the study of molecular characterization of the U.S. stripe rust collections from 2010 to 2017 using 14 SSR markers. From 2,414 isolates, we identified 1,599 multi-locus genotypes (MLGs) and studied the genetic diversity and population differentiation. The results improve the understanding of stripe rust epidemiology and spore movement among different regions in the U.S. 4) We evaluated more than 20,000 wheat and barley entries for resistance to stripe rust. From the tests, we identified new sources of resistance and resistant breeding lines for breeding programs to release new varieties for growers to grow. In 2021, we collaborated with public breeders in releasing, pre-releasing, or registered 14 wheat varieties. The germplasm evaluation data were also used to update the Seed-Buying Guide for growers to choose resistant varieties to grow. 5) We completed a study of identifying a gene for durable high-temperature adult-plant (HTAP) resistance in a wheat near-isogenic line (NIL) for all-stage resistance gene *Yr17* originally from wild grass *Aegilops ventricosa* through ethyl methanesulfonate (EMS) mutagenesis, which separated the HTAP resistance from the *Yr17* resistance. Through phenotyping and genotyping a mapping population, we identified a gene for HTAP resistance and mapped it to the translocated part of chromosome from *Ae. ventricosa*, with the location similar to *Yr17*. This sources of both all-stage resistance gene *Yr17* and the HTAP resistance gene has been widely used in the Pacific Northwest and other regions of the U.S. This study shows the usefulness of the wheat varieties carrying the *Ae. ventricosa* translocation and the importance of combining all-stage resistance with HTAP resistance in developing wheat varieties with durable resistance. 6) In 2021, we published 29 journal articles and 5 meeting abstracts.

Outputs and Outcomes:

WGC project number: 3144				
WGC project title: Improving Control of Rusts of Wheat and Barley				
Project PI(s): Xianming Chen				
Project initiation date: 7/1/2019				
Project year: 3 of 3 (2021)				
Objective	**Deliverable**	**Progress**	**Timeline**	**Communication**
1. Improve the understanding of rust disease epidemiology and the pathogen populations.	**1) New races. 2) Information on distribution, frequency, and changes of all races, and possible fungicide tolerant strains. 3) New tools such as molecular markers and population structures.** The information will be used by breeding programs to choose effective resistance genes for developing new varieties with adequate and durable resistance. We will use the information to select a set of races for screening wheat and barley germplasm and breeding lines. The information is also used for disease management based on races in different regions.	All planned studies for the project in 2021 have been completed on time. There is not any delay, failure, or problem in studies to this objective. The race identification for the 2020 collection was completed and summarized. The data and summary were sent to growers, collaborators and related scientists in March 2021. In the 2021 crop season, we collected and received 301 stripe rust samples throughout the country, of which 159 samples (53%) were collected by ourselves from Washington. We have completed the race ID work for the 2020 samples and detected 18 races of the wheat stripe rust pathogen and 9 races of the barley stripe rust pathogen (including 1 new race), of which all 14 (78%) wheat and 6 (67%, including the new race) barley stripe rust races were detected in Washington. The distribution and frequency of each race and virulence factors in WA and the whole country have been determined. Predominant races have been identified. The information on races and virulence factors is used to guide breeding programs for using effective resistance genes in developing resistant varieties and selected predominant races with different virulence patterns are used in screening for breeding lines of wheat and barley with stripe rust resistance. We have completed the study on molecular charcaterization of the US stripe rust collections from 2010 to 2017 using 14 SSR markers. From 2,414 isolates, we identified 1,599 multi-locus genotypes (MLGs) and studied the genetic diversity and population differentiation. The results improve the understanding of stripe rust epidemiology and spore movement among different regions in the U.S. Using the same set of markers, we have been genotyping the 2018 - 2021 collections. Using the polymorphic simple sequence polymorphisms (SNPs) in the sequences of secreted protein genes associated to virulence genes, we are developing virulence-specific KASP markers for monitoring race changes in the pathogen population. The virulence and molecular studies have improved the understanding the epidemiology, biology and genetics of the pathogen, and provided information and resources for more efficiently monitoring and managing stripe rusts on wheat and barley.	The race identification work for the 2020 stripe rust samples was completed, summarized, and distributed. The race identification work for the 2021 samples has been completed, and the data are being analyzed and summarized. Molecular work for the population genetic studies has been completed and published up to the 2017 collection, completed for the 2018 collection, and is being conducted for the 2019-2021 collections. Preliminary results have been obtained for the development of Kompetitive (KASP) markers for monitoring virulence genes in the rust populations.	The rust race data were communicated to growers and researchers through e-mails, websites, project reports, meeting presentations and publications in scientific journals (for detailed information, see the lists in the main report file).

2. Improve rust resistance in wheat and barley varieties.	**1) Stripe rust reaction data of wheat and barley germplasm and breeding lines. 2) Reactions to other diseases when occur. 3) New resistance genes with their genetic information and molecular markers. 4) New germplasm with improved traits. 5) New varieties for production.** The genetic resources and techniques will be used by breeding programs for developing varieties with diverse genes for stripe rust resistance, which will make the stripe rust control more effective, efficient, and sustainable.	In 2021, we evaluated more than 20,000 wheat, barley, and triticale entries for resistance to stripe rust. The entries included germplasm, breeding lines, rust monitoring nurseries, and genetic populations from various breeding and extension programs. All nurseries were planted at both Pullman and Mt. Vernon locations. Some of the nurseries were also tested in Walla Walla and Lind, WA. Germplasm and breeding lines in the variety trial and regional nurseries also were tested in the greenhouse with selected races of stripe rust for further characterization of resistance. Due to the extremely dry and hot weather conditions, there were no adequte stripe rust in the eastern WA locations although the Pullman sites were inoculated twice. The Mount Vernon site in western WA had severe stripe rust and produced excellent data. The disease data of regional nurseries were provided to all breeding and extension programs, while the data of individual programs' nurseries were provided to the individual breeders. Through these tests, susceptible breeding lines can be eliminated, which should prevent risk of releasing susceptible cultivars and assisted breeding programs to release new cultivars of high yield and quality, good adaptation, and effective disease resistance. In 2021, we collaborated with public breeding programs in releasing and registered 14 wheat varieties. Varieties developed by private breeding programs were also resulted from our germplasm screening program. Through our evaluation, we have established a collection of wheat germplasm with stripe rust resistance, which are valuable sources of stripe rust resistance for further characterization of resistance, identified new effective resistance genes, and for development of wheat varieties with effective resistance. Through our intensive testing, varieties with durable resistance to stripe rust have been developed. In 2021, we completed a study of identifying a gene for durable high-temperature adult-plant (HTAP) resistance in a wheat near-isogenic line (NIL) for all-stage resistance gene *Yr17* originally from wild grass *Aegilops ventricosa* through ethyl methanesulfonate (EMS) mutagenesis, which separated the HTAP resistance from the *Yr17* resistance. Through phenotyping and genotyping a mapping population, we identified a gene for HTAP resistance and mapped it to the translocated part of chromosome from *Ae. ventricosa* , with the location similar to *Yr17* . This study shows the usefulness of the wheat varieties carrying the *Ae. ventricosa* translocation and the importance of combining all-stage resistance with HTAP resistance in developing wheat varieties with durable resistance. In 2021, we completed the phenotyping and genotyping experiments of three whole-genome associate studies (GWAS) including more than 1,300 wheat germplasm lines and are analyzing the data. In 2021, we obtained good stripe rust phenotypic data of 3 bi-parental mapping populations at the Mount Vernon location to validate resistance loci previously identified through the bulked analysis of 40 crosses. We selected new wheat germplasm lines with single new genes or combinations of genes for resistance to stripe rust to make them available for breeding programs and provided seeds to several breeding programs in the United States.	All 2021 germplasm tests were completed, and the data were provided to collaborators on time, although the Pullman sites did not have good rust data due to the drought and hot weather conditions. The 2022 winter wheat nurseries were planted in fields in September and October, 2021. The 2022 spring crop nurseries will be planted in March-April, 2022. We have added the Central Ferry location for the field germplasm screening as the site has the irrigation system. The greenhouse tests of the 2021 spring nurseries and the 2022 winter wheat nurseries have been conducted during this winter, and will be completed by May 2022. All experiments of the molecular mapping studies scheduled for 2021 have been completed. Mapping populations of winter wheat were planted in fields in October, 2021 and those of spring wheat will be planted in April, 2022 for stripe rust phenotype data.	The data of variety trials and regional nurseries were sent to growers and collaborators through e-mails and websites. Summary information of varieties were sent to growers and collaborators through rust updates and recommendations through e-mails, websites, Seed-Buying Guide, and variety release documents. Test data of individual breeding programs were sent to the individual breeders. New genes and molecular markers were reported in scientific meetings and published in scientific journals (see the publication and presentation lists in the report main file).

3. Improve the integrated management of rust diseases.	**1) Data of fungicide efficacy, dosage, and timing of application for control stripe rust. 2) Potential new fungicides. 3) Stripe rust yield loss and fungicide increase data for major commercial varieties. 4) Stripe rust forecasts and updates. 5) Guidance for rust management.** The information is used for developing more effective integrated control program based on individual varieties. Disease updates and recommendations will allow growers to implement appropriate control.	In 2021, stripe rust was forecasted and monitored throughout the 2021 crop season, and rust updates and advises were provided on time to growers. Low stripe rust was forecasted in March and the occurred level was the lowest for the last 30 years due to the extreme dry and hot weather conditions. The recommendations prevented unnecessary use of fungicides, saving growers multimillion dollars. In 2021, we planted field nurseries at Pullman, WA for evaluating 15 fungicide treatments on winter wheat and spring wheat, and 23 winter and 23 spring wheat varieties, plus a non-treated check in each nursery. Due to the dry and hot weather conditions, there was no significant differences in rust severity and no significant difference in grain test weight among the treatments including the non-treated check in the winter wheat fungicide testing nursery, but 10 of the fungicide treatments produced significantly higher grain yields (14-21%) than the non-treated check. However, none of the fungicide treatments in the spring nursery produced higher grain yield than the non-treated check. Similarly, no significant differences in both grain yield and test weight were observed between the fungicide applied and non-applied plots of all 24 winter and 24 spring wheat varieties.	For this objective, all tests scheduled for 2021 were conducted, although the fungicide and variety nurseries did not have adequate rust. For the 2021-22 growing season, the winter wheat plots of the fungicide and variety yield loss studies were planted in October 2021, and the spring plots will be planted in April 2022. The tests will be completed in August (for winter wheat) and September (for spring wheat), 2022.	The results were communicated to growers and collaborators through e-mails, project reports and reviews, and published in scientific journals.

Publications:

Scientific Journals:

Carter, A. H., Balow, K. A., Shelton, G. B., Burke, A. B., Hagemeyer, K. E., Stowe, A., Worapong, J., Higginbotham, R. W., Chen, X. M., Engle, D. A., Murray, T. D., and Morris, C. F. 2021. Registration of 'Devote' soft white winter wheat. Journal of Plant Registrations 15(1):121–131. https://doi.org/10.1002/plr2.20079.

Gill, K. S., Kumar, N., Randhawa, H. S., Murphy, K., Carter, A. H., Morris, C. F., Higginbotham, R. W., Engle, D. A., Guy, S. O., Lyon, D., Murray, T. D., Chen, X. M., and Schillinger, W. F. 2021. Registration of 'Resilience CL+' soft white winter wheat. Journal of Plant Registrations 15(1):196-205. https://doi.org/10.1002/plr2.20118

Carter, A. H., Balow, K. A., Shelton, G. B., Burke, A. B., Hagemeyer, K. E., Stowe, A., Worapong, J., Higginbotham, R. W., Chen, X. M., Engle, D. A., Murray, T. D., and Morris, C. F. 2021. Registration of 'Scorpio' soft white winter wheat. Journal of Plant Registrations 15(1):113-120. https://doi.10.1002/plr2.20076

Mergoum, M., Johnson, J., Buck, J. W., Sutton, S., Lopez, B., Bland, D., Chen, Z., Buntin, G. D., Mailhot, D. J., Babar, Md A. Mason, R. E., Harrison, S. A., Murphy, J. P., Ibrahim, A. M. H., Sutton, R. L., Brown-Guedira, G. L., Simoneaux, B. E., Bockelman, H., Baik, B-. K., Marshall, D., Cowger, C., Kolmer, J. A., Jin, Y., Chen, X. M., Cambron, S. E., and Boyles, R. 2021. Soft red winter wheat, 'GA 051207-14E53': Adapted cultivar to Georgia and the USA Southeast Region. Journal of Plant Registrations 15(1):132-139. https://doi.org/10.1002/plr2.20102

Zhang, G. R., Martin, T. J., Fritz, A. K., Bowden, R. L., Li, Y. H., Bai, G. H., Chen, M.-S., Jin, Y., Chen, X. M., Kolmer, J. A., Seabourn, B. W., Chen, R. Y., and Marshall, D. S. 2021. Registration of 'KS Silverado' hard white winter wheat. Journal of Plant Registrations 15(1):147-153. http://doi.org/10.1002/plr2.20106

Zhang, G. R., Fritz, A. K., Haley, S., Li, Y. H., Bai, G. H., Bowden, R. L., Chen, M.-S., Jin, Y., Chen, X. M., Kolmer, J. A., Seabourn, B. W., Chen, R. Y., and Marshall, D. S. 2021. Registration of 'KS Western Star' hard red winter wheat. Journal of Plant Registrations 15(1):140-146. https://doi.org/10.1002/plr2.20104

Zhang, G. R., Martin, T. J., Fritz, A. K., Li, Y. H., Bai, G. H., Bowden, R. L., Chen, M.-S., Jin, Y., Chen, X. M., Kolmer, J. A., Seabourn, B. W., Chen, R. Y., and Marshall, D. S. 2021. Registration of 'KS Dallas' hard red winter wheat. Journal of Plant Registrations 15(1):154-160. https://doi.org/10.1002/plr2.20108

Carter, A. H., Balow, K. A., Shelton, G. B., Burke, A. B., Hagemeyer, K. E., Stowe, A., Worapong, J., Higginbotham, R. W., Chen, X. M., Engle, D. A., Murray, T. D., and Morris, C. F. 2021. Registration of 'Stingray CL+' soft white winter wheat. Journal of Plant Registrations 15(1):161-171. https://doi.org/10.1002/plr2.20109

Chen, X. M., Evans, C. K., and Sprott, J. A. 2021. Evaluation of foliar fungicides for control of stripe rust on winter wheat in 2020. Plant Disease Management Reports 15:CF028. https://www.plantmanagementnetwork.org/pub/trial/pdmr/reports/2021/CF028.pdf

Chen, X. M., Evans, C. K., and Sprott, J. A. 2021. Evaluation of foliar fungicides for control of stripe rust on spring wheat in 2020. Plant Disease Management Reports 15:CF029. https://www.plantmanagementnetwork.org/pub/trial/pdmr/reports/2021/CF029.pdf

Chen, X. M., Sprott, J. A., Evans, C. K., and Qin, R. 2021. Evaluation of Pacific Northwest winter wheat cultivars to fungicide application for control of stripe rust in 2020. Plant Disease Management Reports 15:CF030.
https://www.plantmanagementnetwork.org/pub/trial/pdmr/reports/2021/CF030.pdf

Chen, X. M., Sprott, J. A., Evans, C. K. 2021. Evaluation of Pacific Northwest spring wheat cultivars to fungicide application for control of stripe rust in 2020. Plant Disease Management Reports 15:CF031.
https://www.plantmanagementnetwork.org/pub/trial/pdmr/reports/2021/CF031.pdf

Brandt, K. M., Chen, X. M., Tabima, J. F., See, D. R., Vining, K. J., and Zemetra, R. S. 2021. QTL analysis of adult plant resistance to stripe rust in a winter wheat recombinant inbred population. Plants 10(3):570. https://doi:10.3390/plants10030572

Sinha, P., and Chen X. M. 2021. Potential infection risks of the wheat stripe rust and stem rust pathogens on barberry in Asia and southeastern Europe. Plants 10(5):957. https://doi.org/10.3390/plants10050957

Mergoum, M., Johnson, J. W., Buck, J. W., Sutton, S., Lopez, B., Bland, D., Chen, Z., Buntin, G. D., Mailhot, D. J., Babar, Md A. Mason, R. E., Harrison, S. A., Murphy, J. P., Ibrahim, Amir M. H., Sutton, R. L., Simoneaux, B. E., Griffey, C. A., Bockelman, H. E., Baik, B-. K., Marshall, D., Cowger, C., Brown-Guedira, G. L., Kolmer, J. A., Jin, Y., Chen, X. M., Boyles, R., and Cambron, S. E. 2021. A new soft red winter wheat cultivar, 'GA 07353-14E19', Adapted to Georgia and the US southeast environments. Journal of Plant Registrations 15(2):337-344. https://doi.org/10.1002/plr2.20113

Bai, Q., Wan, A. M., Wang, M. N., See, D. R., and Chen, X. M. 2021. Population diversity, dynamics, and differentiation of wheat stripe rust pathogen *Puccinia striiformis* f. sp. *tritici* from 2010 to 2017 and comparison with 1968 to 2009 in the United State. Frontiers in Microbiology 12:696835. https://doi.org/10.3389/fmicb.2021.696835

Merrick, L. F., Burke, A. B., Chen, X. M., and Carter, A. H. 2021. Breeding with major and minor genes: genomic selection for quantitative disease resistance. Frontiers in Plant Science 12:713667. https://doi.org/10.3389/fpls.2021.713667

Bai, Q., Wan, A. M., Wang, M. N., See, D. R., Chen, X. M. 2021. Molecular characterization of wheat stripe rust pathogen (*Puccinia striiformis* f. sp. *tritici*) collections from nine countries.

International Journal of Molecular Sciences 22(17):9457 (1-24). https://doi.org/10.3390/ijms22179457

Mergoum, M., Johnson, J. W., Buck, J. W., Sutton, S., Lopez, B., Bland, D., Chen, Z., Buntin, G. D., Mailhot, D. J., Babar, Md A., Mason, R. E., Harrison, S. A., Murphy, J. P., Ibrahim, A. M. H., Sutton, R. L., Simoneaux, B. E., Griffey, C. A., Bockelman, H. E., Baik, B-. K., Marshall, D., Cowger, C., Brown-Guedira, G. L., Kolmer, J. A., Jin, Y., Chen, X. M., Cambron, S. E. 2021. 'GA JT141-14E45': A new soft red winter wheat cultivar adapted to Georgia and the U.S. Southeast region. Journal of Plant Registrations 15(3):471-478. https://doi.org/10.1002/plr2.20070

Garland Campbell, K., Allan, R. E., Burke, A., Chen, X. M., DeMacon, P., Higginbotham, R., Engle, D., Johnson, S., Jones, S., Klarquist, E., Mundt, C. C., Murray, T. D., Morris, C., See, D., and Wen, N. 2021. Registration of 'ARS Crescent' soft white winter club wheat. Journal of Plant Registrations 15(3):515-526. http://doi.org/10.1002/plr2.20135

Garland Campbell, K., Allan, R. E., Carter, A. H., DeMacon, P., Klarquist, E., Wen, N., Chen, X. M., Steber, C. M., Morris, C., See, D., Esser, A., Engle, D., Higginbotham, R., Mundt, C., and Murray, T. D. 2021. Registration of 'Castella' soft white winter club wheat. Journal of Plant Registrations 15(3):504-514. https://doi.org/10.1002/plr2.20132

Wang, J. H., Wang, J. J., Li, J., Shang, H. S., Chen, X. M., and Hu, X. P. 2020. The RLK protein TaCRK10 activates wheat high-temperature seedling plant resistance to stripe rust through interacting with TaH2A.1. The Plant Journal 108:1241–1255. https://doi:10.1111/tpj.15513

Aoun, M., Chen, X. M., Somo, M., Xu, S. S., Li, X. H., and Elias, E. M. 2021. Novel stripe rust all-stage resistance loci identified in a worldwide collection of durum wheat using genome-wide association mapping. The Plant Genome 14:e20136(1-18). https://doi.org/10.1002/tpg2.20136

Chen, X. M., Wang, M. N., Wan, A. M., Bai, Q., Li, M. J., López, P. F., Maccaferri, M., Mastrangelo, A. M., Barnes, C. W., Cruz, D. F. C., Tenuta, A. U., Esmail, S. M., and Abdelrhim, A. S. 2021. Virulence characterization of *Puccinia striiformis* f. sp. *tritici* collections from six countries in 2013 to 2020. Canadian Journal of Plant Pathology 43(2):S308-S322. https://doi.org/10.1080/07060661.2021.1958259

Liu, T. L., Bai, Q., Wang, M. N., Li, Y. X., Wan, A. M., See, D. R., Xia, C. J., and Chen, X. M. 2021. Genotyping *Puccinia striiformis* f. sp. *tritici* isolates with SSR and SP-SNP markers reveals dynamics of the wheat stripe rust pathogen in the United States from 1968 to 2009 and identifies avirulence associated markers. Phytopathology 111(10):1828-1839. https://doi.org/10.1094/PHYTO-01-21-0010-R

Yao, F. J., Guan, F. N., Duan, L. Y., Long, L., Tang, H., Jiang, Y. F., Li, H., Jiang Q. T., Wang, J. R., Qi, P. F., Kang, H. Y., Li, W., Ma, J., Pu, Z. E., Deng, M., Wei, Y. M., Zheng, Y. L., Chen, X. M., and Chen G. Y. 2021. Genome-wide association analysis of stable stripe rust resistance loci in a Chinese wheat landrace panel using the 660K SNP array. Frontiers in Plant Science 12:783830. https://doi.org/10.3389/fpls.2021.783830

Chen, W., Zhang, Z. D., Chen, X. M., Meng, Y., Huang, L. L., Kang, Z. S., and Zhao, J. 2021. Field production, germinability, and survival of *Puccinia striiformis* f. sp. *tritici* teliospores in China. Plant Disease 105(8):2122-2128. https://doi.org/10.1094/PDIS-09-20-2018-RE

Hu, Y. S., Tao, F., Su, C., Zhang, Y., Li, J., Wang, J. H., Xu, X. M., Chen, X. M., Shang, H. S., Hu, X. P. 2021. NBS-LRR gene *TaRPS2* is positively associated with the high-temperature seedling-plant resistance of wheat against *Puccinia striiformis* f. sp. *tritici*. Phytopathology 111(8):1449-1458. https://doi.org/10.1094/PHYTO-03-20-0063-R

Wang, Y. Q., Yu, C., Cheng, Y. K., Yao, F. J., Long, L., Wu, Y., Li, J., Li, H., Wang, J. R., Jiang, Q. T., Wei, L., Pu, Z. E., Qi, P. F., Ma, J., Deng, M., Wei, Y. M., Chen, X. M., Chen, G. Y., Kang, H. Y., Jiang, Y. F., and Zheng, Y. L. 2021. Genome-wide association mapping reveals potential novel loci controlling stripe-rust resistance in a Chinese wheat landrace diversity panel from the southern autumn-sown spring wheat zone. BMC Genomics 22:34(1-15). https://doi.org/10.1186/s12864-020-07331-1

Popular Press Articles:

January 7, 2021. 2021 First Stripe Rust Forecast and 2020 Variety Yield Loss and Fungicide Tests. Xianming Chen, E-mail sent to cereal group. https://striperust.wsu.edu/2021/01/12/2021-first-stripe-rust-forecast-and-2020-variety-yield-loss-and-fungicide-tests-january-7-2021/

March 15, 2021. Stripe Rust Forecast and Update, March 15, 2021. Xianming Chen, E-mail sent to cereal group. https://striperust.wsu.edu/2021/03/15/stripe-rust-forecast-and-update-march-15-2021/

April 16, 2021. Stripe Rust Update, April 16, 2021. Xianming Chen, E-mail sent to cereal group. https://striperust.wsu.edu/2021/04/19/stripe-rust-update-april-16-2021/

May 13, 2021. Stripe Rust Update, May 13, 2021. Xianming Chen, E-mail sent to cereal group. https://striperust.wsu.edu/2021/05/14/stripe-rust-update-may-13-2021/

May 28, 2021. Stripe Rust Update, May 28, 2021. Xianming Chen, E-mail sent to cereal group. https://striperust.wsu.edu/2021/06/01/stripe-rust-update-may-28-2021/

Presentations and Reports:

In 2021, Xianming Chen and associates presented invited talks at the following regional, national, and international meetings:

"Races of *Puccinia striiformis* f. sp. *tritici* and stripe rust resistance relevant to the hard red winter wheat region" for the Plenary Session of Stripe Rust at 2021 Hard Winter Wheat Rust Symposium, April 6, 2021, Oral presentation (Virtual meeting).

"Recent Progress in Stripe Rust Research" at Hermiston Irrigated Cereal Field Day, June 14, 2021, Oral presentation (Virtual meeting).

Attended the American Phytopathological Society (APS) Pacific Division Annual Meeting (Virtual) and presented "Molecular characterization of international collections of wheat stripe rust pathogen *Puccinia striiformis* f. sp. *tritici*" (Authors: Qing Bai, Anmin Wan, Meinan Wang, Deven See, and Xianming Chen), Student oral presentation, June 16-18, 2021 (Virtual meeting).

Attended the APS Plant Health 2021 annual meeting (virtual) and presented 1) "Stripe rust epidemics of wheat and barley and races of *Puccinia striiformis* identified in the United States in 2020" (Authors: Meinan Wang and Xianming Chen), poster presentation; 2) "Population diversity, differentiation, and dynamics of barley stripe rust pathogen *Puccinia striiformis* f. sp. *hordei* in comparison with wheat stripe rust pathogen *P. striiformis* f. sp. *tritici* in the United States" (Authors: Qing Bai, Anmin Wan, Meinan Wang, Deven See, and Xianming Chen), Qing Bai oral presentation, August 1-4, 2021 (Virtual meeting).

Attended the Global Plant Health Assessment Workshop and presented an invited talk "Wheat Health Assessment", October 4-8, 2021 (Toulouse France & Virtual).

Attended the Borlaug Global Rust Initiative (BGRI) 2021 Technique Workshop and presented poster "Identification of High-temperature Adult-plant (HTAP) Resistance to Stripe Rust through Developing EMS Mutants from the *Yr17* Near Isogenic Line and Molecular Mapping of the HTAP Resistance Gene to the *Aegilops ventricosa* Translocation Chromosomal Region". October 6-8, 2021 (Virtual).

Reports:

Report of race summaries of the 2020 stripe rust collection in the US. March 2021. https://striperust.wsu.edu/races/data/

Stripe data of more than 50 wheat and barley germplasm nurseries tested in 2021. July 29 – August 25, 2021. https://striperust.wsu.edu/nursery-data/2020-nursery-data/

Chen, X. M., Evans, K. C, Wang, M. N., Sprott, J., Bai, Q., Liu, L., Li, Y. X., Mu, J. M., and Kudsk, A. M. 2021. Cereal Rust Management and Research in 2020. Page 22 in: 2021 Field Day Abstracts: Highlights of Research Progress, https://s3.us-west-2.amazonaws.com/css.wsu.edu/wp-content/uploads/2021/06/10071231/FDA-2021.pdf