FY21 Performance Progress Report

Due date: July 26, 2022

Cover Page
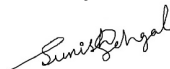
Principle Investigator (PI):	Sunish Sehgal
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Phone:	605-688-5709
Fiscal Year:	2021
USDA-ARS Agreement ID:	59-0206-0-117
USDA-ARS Agreement Title:	Winter Wheat Breeding for Scab Resistance in South Dakota
FY20 USDA-ARS Award Amount:	$140,466
Recipient Organization:	South Dakota State University Plant Science Department 2380 Research Parkway, 1113B Seed Technoligy Brookings, SD 57006-1096
DUNS Number:	929929743
EIN:	46-6000364
Recipient Identifying Number or Account Number, if any:	SA2000532
Project/Grant Period:	5/6/21 - 5/5/23
Reporting Period End Date:	5/4/2022

USWBSI Individual Project(s)

USWBSI Research Category[*]	Project Title	ARS Award Amount
HWW-CP	Developing Winter Wheat Varieties with Enhanced Resistance to FHB and low DON	$95,453
HWW-CP	Innovated Selection Plan to Improve the FHB Resistance of Hard Winter Wheat	$6,985
GDER	EMS Mutagenized Populations for Characterization of Resistance to FHB in Wheat	$38,028
FY21 Total ARS Award Amount		$140,466

I am submitting this report as an: ☒ Annual Report   ☐ Final Report

I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.

_____   7/24/22 _____

Principal Investigator Signature   Date Report Submitted

Project 1: Developing Winter Wheat Varieties with Enhanced Resistance to FHB and low DON

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1. **What are the major goals and objectives of the research project?**
   The major goal of this project was to successfully address USWBSI – HWW-CP priorities, which are to develop high-yielding and high-quality hard winter wheat varieties with improved resistance to FHB and lower DON content. The specific objectives of this proposal are (1a) Increase the efficiency of coordinated project breeding programs to develop and release FHB resistant varieties, (1b) Test and evaluate regional germplasm to include breeding lines from the public and private breeding programs in mist-irrigated field nurseries, (2) Enhance selection efficiency through technologies such as genomic selection, marker-assisted selection, doubled haploid production, leading to pyramiding of major and minor genes for FHB resistance.

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

 a) **What were the major activities?**
  1. Evaluate Hard Winter Wheat (HWW) cultivars from the region, advanced breeding lines, and germplasm in the mist-irrigated inoculated FHB nursery. Utilization of FHB resistant genotypes as parents in crosses and advance most resistant breeding lines with the lowest disease index, FDK, and DON content.
  2. Participation in multi-location regional screening under the mist-irrigated inoculated FHB nursery (i.e. Regional HWW FHB Nursery).
  3. Marker-assisted selection to enhance FHB resistance in SD germplasm.

 b) **What were the significant results?**
  1. Data was collected on 46 Elite, 126 Advanced Yield Trial entries from the SDSU winter wheat breeding program in mist irrigated FHB nurseries. Four advanced breeding lines SD15035-2, SD17B032-1 SD17B210-2, and SD18B025-8 performed well in the state trials and ranked among the top 10 in Northern Regional Performance Nursery (NRPN) in 2021. SD12DHA01373 was released as a new variety (SD Midland) with good yield potential and excellent quality and moderate resistance to stripe rust and average FHB tolerance. Advanced breeding line SD15035-2 showed good yield potential and above-average FHB resistance in 2021. If SD15035-2 performs well in 2022, it may be released in fall 2022.
  2. The FHB disease ratings on regional germplasm in the Northern Hard Winter Wheat FHB Public and Private Nurseries and South Dakota CPT is made available to South Dakota producers, and colleagues at other participating institutions and private industries.
  3. More than 120 crosses were made specifically for FHB resistance and about 35 marker-assisted backcrosses were advanced BC1F3 made to incorporate Fhb1 into the South Dakota germplasm and combine with native FHB resistance. Additionally, promising lines from Lyman x Emerson are in early observation trials for the evaluation of yield and agronomic traits in 2022.

c) **List key outcomes or other achievements.**

The major outcome was the release of 'SD Midland' hard red winter wheat for central and western South Dakota. SD Midland is semi-dwarf wheat (RhtD1b) and is expected to offer the producers a higher-yielding winter wheat variety with good straw strength, winter hardiness, and good stripe rust resistance. It has excellent milling and baking characteristics. It has an average tolerance to FHB.

3. **What opportunities for training and professional development has the project provided?**
Two graduate students Jinfeng Zhang and Anshul Rana (partially supported by the project) and two undergraduate students got hands-on training/experience in day-to-day operations of the breeding program and FHB screening nursery during this period. Additionally, students assisted with collecting Fusarium damaged kernel (FDK) scores and helped in the preparation of samples for DON analysis.
Anshul presented her work at Gamma Sigma Delta Poster Competition at SDSU

4. **How have the results been disseminated to communities of interest?**
FHB resistance ratings collected on released cultivars are made available to growers as a part of the annual South Dakota Crop Performance Testing Hard Winter Wheat report. Additionally, data collected from Northern Hard Winter Wheat FHB Public and Private Nurseries is shared back with colleagues from both public and private breeding programs. The results from this project were shared through five field days including a virtual field day in 2021 and through articles in appropriate popular press sources, word of mouth, Twitter, brochures, and Extension press releases from the Agricultural Experiment Station.

Project 2: Innovated Selection Plan to Improve the FHB Resistance of Hard Winter Wheat

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1. **What are the major goals and objectives of the research project?**
   Our goal is to develop HWW cultivars that are resistant to FHB and accumulate reduced levels of DON following infection. Specifically, we will address the following objectives and associated research activities: 1. Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties; and Objective 2, associated activity 2. Enhance selection efficiency through technologies such as genomic selection, marker-assisted selection, doubled haploid production and/or high throughput phenotyping leading to pyramiding of major and minor genes for FHB resistance.

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

   a) **What were the major activities?**
      200 lines from South Dakota were phenotyped both in Ohio (Dr. Clay Sneller) and South Dakota in 2020 and 2021. The lines were also genotyped. Genomic prediction models were evaluated and will be updated in 2022.

   b) **What were the significant results?**
      Of the SDSU lines evaluated in 2021 at OSU, 22.5% of the lines had scores similar to or better than Truman (R), demonstrating that SDSU material has native resistance. Genomic prediction (GP) using data from multiple years (2018, 2019, and 2020) from South Dakota evaluations showed promise. We observed a moderate PA using univariate models for DIS (0.39 and 0.35) and FDK (0.35 and 0.37) using TP19 and TP20, respectively, while slightly higher PA was observed (0.41 for DIS and 0.38 for FDK) when TP19 and TP20 (TP19 + 20) were combined to leverage the advantage of a large training population. Although GP with multivariate approach including plant height and days to heading as covariates did not significantly improve PA for DIS and FDK over univariate models, the PA for DON increased by 20% using DIS, FDK, DTH as covariates using multi-trait model in 2020. Finally, we used TP19, TP20, and TP19 + 20 in forward prediction to calculate genomic-estimated breeding values (GEBVs) for DIS and FDK in preliminary breeding lines at an early stage of the breeding program. We observed moderate PA of up to 0.59 for DIS and 0.54 for FDK, demonstrating the promise in genomic prediction for FHB resistance in earlier stages using advanced lines.

   c) **List key outcomes or other achievements.**

      Genomic prediction for FHB traits like DON and FDK can facilitate the rejection of highly susceptible materials at an early stage in a breeding program. One manuscript was published from this study.

3. **What opportunities for training and professional development has the project provided?**
   One graduate student Jinfeng Zhang and another graduate student Harsimardeep Gill (not supported by this grant) got hands-on training in genomic data analysis and genomic prediction.

4. **How have the results been disseminated to communities of interest?**

   The results from this project were shared through five field days including a virtual field day in 2021 and through research articles, twitter, brochures, and Extension press releases from the Agricultural Experiment Station.

Project 3: EMS Mutagenized Populations for Characterization of Resistance to FHB in Wheat

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1. **What are the major goals and objectives of the research project?**
    The goals of the project are 1) to develop and evaluate EMS mutagenized M2 derived M4 lines in spring wheat cultivars for finding resistance against FHB, 2) to develop a TILLING resource for characterization of genes that could play role in FHB resistance.

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

    a) **What were the major activities?**
        We are developing EMS mutagenized populations in two wheat cultivars RB07 (MR) and Berkut (S) to identify FHB resistant and susceptibility mutants. Further, we are developing a TILLING resource for these two wheat cultivars.

    b) **What were the significant results?**

        In 2021, we harvested seeds from 715 M_2's from 900 Berkut M_2s, the rest of the M_2 lines were sterile. The M3 generation seed increase is underway in the greenhouse. For RB07, the seed increase of 487 M_3's is also progressing. Leaf tissues from M2 plants from both populations were collected and DNA extraction is underway to develop TILLING pools.
        Previously screening on 750 M4 RB07 for FHB under a mist irrigated nursery identified two M4 lines (in RB07 background) highly susceptible to FHB were identified and crossed RB07 (wild type) to develop a RIL mapping population.

    c) **List key outcomes or other achievements.**
        FHB susceptible mutants in RB07 background were identified.

3. **What opportunities for training and professional development has the project provided?**

    One graduate student (Anshul Rana) got hands-on training in mutagenesis and FHB screening and presented a poster in Gamma Sigma Delta Poster Competition at SDSU Brookings, SD.

4. **How have the results been disseminated to communities of interest?**

    The results from this project were shared through five field days and through poster presentations and social media.

Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your FHB work that were a result of funding from your FY21 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period** should be included.

Did you publish/submit or present anything during this award period?

☒ Yes, I've included the citation reference in listing(s) below.

☐ No, I have nothing to report.

Journal publications as a result of FY21 grant award

List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Include any peer-reviewed publication in the periodically published proceedings of a scientific society, a conference, or the like.

Jinfeng Zhang, Harsimardeep S. Gill, Navreet K. Brar, Jyotirmoy Halder, Shaukat Ali, Xiaotian Liu, Amy Bernardo, Paul St. Amand, Guihua Bai, Upinder S. Gill, Brent Turnipseed, Sunish K. Sehgal, Genomic prediction of Fusarium head blight resistance in early stages using advanced breeding lines in hard winter wheat, *The Crop Journal, early online,* published https://doi.org/10.1016/j.cj.2022.03.010

Acknowledgment of federal support: Yes

Books or other non-periodical, one-time publications as a result of FY21 grant award

Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like.

Other publications, conference papers and presentations as a result of FY21 grant award

Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication.

Sunish K Sehgal, Jinfeng Zhang, Harsimardeep S. Gill, Navreet K Brar, Jyotirmoy Halder, Shaukat Ali, Xiaotian Liu, Amy Bernardo, Paul St Amand, Guihua Bai, Brent Turnipseed, Breeding for FHB Resistance in Hard Winter Wheat. *Proceedings of the 2021 National Fusarium Head Blight Forum*; Virtual. December 6-7, 2021. Retrieved from: https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf

Acknowledgment of Federal Support: Yes

Release Notice: Release of 'SD Midland' Hard Red Winter Wheat by South Dakota Agricultural Experiment Station, South Dakota State University, December 15, 2021.

Acknowledgment of Federal Support: Yes

Anshul Rana, Jinfeng Zhang, Harsimardeep S. Gill, Sunish K. Sehgal, Fast Forwarding Wheat Breeding for Fusarium Head Blight Resistance, Gamma Sigma Delta Poster Competition, April 20, 2022, (poster presentation)

Acknowledgment of Federal Support: Yes

Swas Kaushal, Nawaz Shahid, Anshul Rana, Jyotirmoy Halder, Maitiniyazi Maimaitijiang, Ali Nafchi, Sunish K. Sehgal, Gamma Sigma Delta Poster Competition, April 20, 2022, (poster presentation)

Acknowledgment of Federal Support: Yes

(Form – PPR21)