United States Department of Agriculture

Progress Report

Title:	Increasing Low-Input Turfgrass Adoption Through Breeding, Innovation, and Public Education

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Submitted By		**Date Submitted to NIFA**	

Program Code: SCRI **Program Name:** Specialty Crop Research Initiative

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Non-Technical Summary

The public desires lower-input turfgrasses that provide functional turf areas while reducing inputs of water, fertilizer, mowing, and pesticides. We propose that the fine fescues, an important group of grasses well-suited to low-input environments, should be able to provide these types of turf areas. Surveys of consumer and public land managers suggests that having knowledge about the positive benefits of fine fescues is not enough to increase adoption. The long-term goal of this project is to increase the use of well-adapted fine fescue cultivars in sustainable landscapes. In our first objective, we will survey consumers, land managers, and seed producers to identify the barriers preventing them from using fine fescues. In the second objective, we will lead a sustained effort of cultivar development focused on improving important traits utilizing new molecular technologies and proven breeding approaches. The third objective will generate new knowledge about complex interactions between turfgrass genetics and management. Our approach in the fourth objective will use 30 years of publically available data in an innovative way to improve consumer turfgrass purchasing decisions for improved fine fescue cultivars. Our fifth objective will identify solutions to several turfgrass management barriers that are preventing stakeholders from seeding fine fescues in landscapes and seed producers from growing this specialty crop. Finally, and most importantly, our sixth objective will deliver research-based information to consumers, seed producers, and land managers using new and innovative outreach methods. We will use plant breeding to improve low-input characteristics and increase the production and profitability of this specialty crop over the long-term.

Accomplishments

Major goals of the project

The long-term goal of this project is to increase the use of well-adapted fine fescue cultivars in sustainable landscapes. In our first objective, we will survey consumers, land managers, and seed producers to identify the barriers preventing them from using fine fescues. In the second objective, we will lead a sustained effort of cultivar development focused on improving important traits utilizing new molecular technologies and proven breeding approaches. The third objective will generate new knowledge about complex interactions between turfgrass genetics and management. Our approach in the fourth objective will use 30 years of publically available data in an innovative way to improve consumer turfgrass purchasing decisions for improved fine fescue cultivars. Our fifth objective will identify solutions to several turfgrass management barriers that are preventing stakeholders from seeding fine fescues in landscapes and seed producers from growing this specialty crop. Finally, and most importantly, our sixth objective will deliver research-based information to consumers, seed producers, and land managers using new and innovative outreach methods. We will use plant breeding to improve low-input characteristics and increase the production and profitability of this specialty crop over the long-term. Output of this research will include new tools for consumers to use when making grass seed purchasing decisions, new turfgrass seed cultivars with improved low-input adaptation, new knowledge about the stress tolerance of fine fescues, new tools for public and private plant breeders to use when selecting fine fescues

What was accomplished under these goals?

As part of our first objective, we have developed consumer surveys to investigate the barriers and incentives to adopt low-input turfgrasses. The survey was then distributed to consumers and the survey data was collected; these results can help inform our research on management of fine fescues and help direct our outreach efforts. We have also finished analyzing the survey data about user preferences for public turfgrass performance data; these results have been published and are being used in Objective 4. Additional work has involved collaborating with college and university Sustainability and Facilities Management offices to develop fine fescue demonstration sites at universities in seven states. We completed data analysis for six focus group discussions with public land managers in Indiana, Oregon, & New Jersey related to fine fescue implementation. We then developed a summary of findings for the research team and hosted an exercise that elicited research team and advisory board member responses to public land manager concerns. The findings and responses were refined for an online outreach summary. We completed interviews at Minnesota, Oregon State, Purdue, & Rutgers, with decision makers regarding campus vegetation transitions. Interviews were transcribed and analyzed.
In Objective 2, we developed markers useful for the identification of the major fine fescue taxa, which will help breeders and other researchers properly classify germplasm accessions, a very difficult task due to morphological similarity. Genomics work on hard fescue is ongoing; a total of 643Gb of PacBio Sequel reads (N50 of approximately 20kb) were generated for a 'Beacon' hard fescue genome. Heat stress tolerance is an important trait in fine fescues. We performed biochemical analysis and found that superior heat tolerance in 'Reliant IV', compared to 'Predator', was associated with active amino acid metabolism and the production of secondary metabolites involving antioxidant activity. Comparative transcriptomic analysis for two cultivars with contrasting response to heat stress indicated early transcriptomic responses to heat stress in the heat-tolerant cultivar. Heat stress for 14 d led to more transcript changes in 'Predator', reflecting late transcriptomic responses to heat stress in the heat-sensitive cultivar. Gene ontology analysis found that many genes enriched in 'Reliant IV' in response to heat stress are involved in oxidation-reduction process, oxidoreductase activity, oxylipin metabolic process, and transcription factor activity, suggesting the importance of those metabolic pathways in fine fescue heat tolerance. Although known for their shade tolerance, the fine fescues differ in how they respond to reduction in light quality. We have screened a number of fine fescue cultivars and found that strong creeping red fescue and Chewings fescue perform the best under light conditions similar to those found under vegetative shade while hard fescues do not perform as well. Based on this new knowledge, we have developed a system for screening breeding material using photoselective filters that should hasten the development of new fine fescue cultivars with enhanced shade tolerance. We have continued work towards improving our understanding of traffic tolerance of the fine fescues. Fiber analysis of approximately 120 clones of fine fescues is ongoing. This data will be used to associate with the traffic tolerance assessment made on the same clones in 2018. Breeding for resistance to summer patch disease will be critical for the success of fine fescues. A summer patch heritability study was established in May of 2017 and inoculated with both M. meyeri-festucae and M. poae in the summer of 2018. Another location of this experiment was established in the summer of 2019 and also inoculated with the same isolates. Both locations exhibited summer patch disease. Visual evaluation of summer patch disease was conducted in September of 2019 on both trials and confirmed to be summer patch disease. The population with largest variance for summer patch resistance was the cross between the tolerant and susceptible parents. Progeny from this cross were vegetatively propagated and established in the greenhouse. This population will be used for mapping QTL for summer patch resistance.
Objective 3 is focused on the biology of summer patch disease. Team members at Rutgers isolated 42 fungal strains from eight fine fescue samples with summer patch symptoms. Based on DNA barcoding phylogeny, 17 isolates from New Jersey

were identified as Magnaporthiopsis meyeri-festucae, and seven isolates from Indiana were identified as M. cynodontis. We inoculated Beacon hard fescue seedlings with one M. poae and ten M. meyeri-festucae isolates in the laboratory and observed hyphopodium and runner hyphae structures. Strains were provided to collaborators for further growth chamber inoculations. Isolates of Magnaporthiopsis poae and M. festuca-meyeri were screened for pathogenicity on hard fescue and Kentucky bluegrass at two air temperatures in growth chambers to assure isolates used in the field work are highly pathogenic. In addition, hard fescue turf was established in a field plot where it will be used to evaluate soil pH and N fertilizer source effects on summer patch disease. We are attempting to develop a fast and efficient recombinase polymerase amplification (RPA) assay to detect and differentiate root-infecting pathogens of fine fescue in the field.
In Objective 4, we are working to increase the accessibility of turfgrass evaluation data on fine fescues for consumers. We have analyzed user preferences based on survey responses. Using the results and feedback from turfgrass researchers, we have refined and finalized our database design by creating a more detailed and extensible Entity-Relationship diagram. The design has been validated by turfgrass researchers, National Turfgrass Evaluation Program advisory board members, and others. We have also implemented the database and tested its feasibility and execution-time for user queries. To further improve the convenience of user query, we have developed a prototype web-application allowing homeowners to find the most suitable cultivar with a few clicks.
In Objective 5 we are developing fine fescue best management practices for both managed turf and seed production systems. Team members from Purdue and Oregon State initiated a patch and repair mulch trial to assess establishment and performance of a fine fescue mix, with and without fertility, along with various different mulch sources. The optimal seeding date trial to determine fine fescue seeding times is ongoing at multiple locations. Data was collected in IN, MN, OR, and NJ with the objectives to quantify maintenance inputs, compare new and old cultivars, and quantify mowing requirements of fine fescues compared to other turf species. A fine fescue fertilization establishment trial was initiated to observe nitrogen requirements at establishment on individual species.
Fine fescue seed production is critical to increased use by consumers. In 2019, we completed year 2 of on-farm trials in Oregon to evaluate seed yield and yield component effects of different nitrogen and plant growth regulator (PGR) treatments on Chewings and creeping red fescue in the absence of field burning. We also initiated a spring mowing X plant growth regulator trial the Oregon State Hyslop Research Farm. There are two spring mowing treatments and four PGR treatments on both Chewings and creeping red fescues. Seed yield and seed yield components were determined.
Finally, for Objective 6, we have been active in outreach to professional groups and other stakeholders. Several "LowInputTurf" social media accounts are actively being used across several platforms as a way to reach the general public.

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

Researchers and postdoctoral associates are mentoring graduate students in methodology used in this project.

How have the results been disseminated to communities of interest?

Presentations were given at field days at participating institutions. These field days were attended by our target audience including turfgrass industry professionals (golf course superintendents, public land managers, athletic field managers, parks managers, seed sales people, etc.), as well as homeowners. Research results were also presented at annual conferences. Several research presentations were given at the Crop Science Society of America annual meeting to inform the scientific community about our work. Students in undergraduate courses were also presented with results from this work during lecture and discussion sessions focused on sustainable turfgrass management.

What do you plan to do during the next reporting period to accomplish the goals?

For Objective 1, the socio-economics team will start to clean and analyze the consumer survey data. Econometric/statistical models will be set up and tested to analyze the data. We aim to complete and submit one paper during the next reporting period. The team will start to draft the producer survey to investigate their barriers/incentives to adopt low-input turfgrasses. We will continue our work on identifying barriers for homeowners and public land managers and also complete two academic articles: institutional transitions in vegetation and public land manager perceptions of opportunities and barriers for the use of fine fescues. Finally, we will work on the development of a curriculum toolkit for undergraduate students to engage in fine fescue research using the demonstration plots.
For Objective 2, we will implement new approaches for molecular identification of fine fescues in our breeding programs. The genomics team will assemble the hard fescue genome using the MECAT algorithm, and obtain EST sequences for an annotation (GFF) file using PacBio IsoSeq and Illumina PE 150 reads. We will continue bioinformatics analysis from the transcriptome for 'Reliant IV' and 'Predator' to look for specific genes and gene networks, as well as transcriptional factors that may explain the genetic variation in heat tolerance between the two fine fescue cultivars. Our newly-developed approach to screening for plant response to reduced light quality (low red:far red light) will be used to screen fine fescue breeding germplasm. We will complete fiber analysis of approximately 120 clones of hard, Chewings, and strong creeping red fescues

and associate those constituents with traffic tolerance assessments made on the same clones during 2018. For the summer patch heritability study, there are now three locations for summer patch evaluation. We plan to calculate narrow-sense heritability of summer patch resistance from three environments and prepare a refereed publication. A segregating population for summer patch disease susceptibility will be genotyped using ddRAD sequencing in order to develop a genetic linkage map and identify QTL associated with summer patch resistance in hard fescue. The parents will also be inoculated with the pathogen under controlled conditions and a transcriptome analysis will be conducted to identify genes involved with the disease response in hard fescue.
In Objective 3, new RPA primers for the various root fungi were recently ordered and work will be conducted during the winter of 2019-2020 to create an effective RPA assay to use in the field in 2020. In addition, we anticipate screening fine fescue breeding lines produced by other collaborators for resistance to Microdochium patch and Typhula blight. Plant pathologists at Rutgers will continue collecting, isolating and identifying summer patch pathogens from broad geographical areas in North America. Pathogenicity and virulence tests will be conducted and the most virulent strains will be selected for field inoculation experiments. The geographical distribution and population genetic data also will be analyzed to better understand the pathogen's dispersal and impact to fine fescue. Additionally, we will complete a second growth chamber screen to confirm the pathogenicity of Magnaporthiopsis poae and M. festuca-meyeri isolates on hard fescue and Kentucky bluegrass. We will inoculate hard fescue turf field plots with Magnaporthiopsis poae and M. festuca-meyeri isolates shown to be pathogenic in growth chamber studies and evaluate the effects of soil pH and N fertilizer sources on summer patch.
After presenting our database work from Objective 4 to the National Turfgrass Evaluation Program, advisory board members were motivated by its potential in improving data management and have voted to add data of all species beyond fine-fescue into the database. Thus, the next step will be to further evaluate the flexibility of the database in storing and querying the new data. We will also continue to incorporate new fine-fescue data and further test the correctness of the database by comparing query results with manual results (e.g., summary tables from the NTEP website). Finally, we will move the database to a production server for more extensive user testing and refine the prototype web-application (e.g., flexibility, convenience).
As part of Objective 5, we will continue the field research on turf best management practices. We plan to finish both the on-farm N X PGR trials and the spring mowing X PGR trial. We will conduct another focus group meeting with the industry participants to report outcomes. Extension publications and/or peer-reviewed manuscripts will be started once the final year of data has been compiled and analyzed. Turfgrass management trials will continue and data will be communicated to the project team and presented to stakeholder groups as it becomes available.
For Objective 6, as part of our outreach activities,we will publish a literature review on fine fescues that can help inform the research community about possible future research directions. A master PowerPoint presentation and extension publication on fine fescues will be disseminated among collaborators to edit, use, and share with county and regional extension educators for use in consumer and professional education.

Participants

Actual FTE's for this Reporting Period

Role	Non-Students or faculty	Students with Staffing Roles			Computed Total by Role
		Undergraduate	Graduate	Post-Doctorate	
Scientist	1.2	0	3.2	3.4	7.800000000000001
Professional	0.3	0	0	0	0.3
Technical	2.9	0	0	0	2.9
Administrative	0	0	0	0	0
Other	0	0	0	0	0
Computed Total	4.4	0	3.2	3.4	11.000000000000001

Student Count by Classification of Instructional Programs (CIP) Code

Undergraduate	Graduate	Post-Doctorate	CIP Code

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Undergraduate	Graduate	Post-Doctorate	CIP Code
4	3	4	01.06 Applied Horticulture and Horticultural Business Services.
	2		45.11 Sociology.
	1		52.14 Marketing.
	1		11.07 Computer Science.

Target Audience

Target audiences include professional turfgrass managers, home lawn care professionals, homeowners, Master Gardeners, and seed producers. These groups have been reached through various means including presentations and online communication. We have also reached a significant scientific audience through peer reviewed publications and research seminars at conferences.

Products

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2019	NO

Citation

Qu, Y., R.M. Daddio, P.E. McCullough, S.A. Bonos and W.A. Meyer. 2019. Phytotoxicity of methiozolin on fine fescue. HortTechnology 29: 265-270.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2018	YES

Citation

Wang, J., B. Yuan, Y. Xu, and B. Huang. 2018. Differential responses of amino acids and soluble proteins to heat stress associated with genetic variations in heat tolerance for hard fescue (Festuca trachyphylla). J. Am. Soc. Hort. Sci. 143(1):45–55.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2019	NO

Citation

Wang, J., B. Yuan, and B. Huang. 2019. Differential heat-induced changes in phenolic acids associated with genotypic variations in heat tolerance for hard fescue. Crop Sci. 59:667-674.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2019	YES

Citation

Yue, C., J. Wang, E. Watkins, Y. Xie, S. Shekhar, S.A. Bonos, A. Patton, K. Morris, and K. Moncada. 2019. User preferences for accessing publically available turfgrass cultivar performance data. HortTechnology 1:1-12.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2019	YES

Citation

Yue, C., J. Wang, E. Watkins, S.A. Bonos, K.C. Nelson, J.A. Murphy, W.A. Meyer, and B.P. Horgan. 2019. Investigating the practices and challenges for turfgrass breeders and distributors. Hortscience 54:129-135.

doi:10.21273/hortsci13343-18.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2018	YES

Citation

Qiu, Y., C. Hirsch, and E. Watkins. 2018. Complete chloroplast genome sequence of hard fescue (Festuca brevipila). ASA-CSSA International Meeting. Baltimore, MD. (Oral presentation).

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2018	YES

Citation

Qiu, Y. 2018. Developing a quick test to distinguish fine fescue species in mixtures. University of Minnesota Turfgrass Science website, October 10, 2018. (blog post). https://turf.umn.edu/news/developing-quick-test-distinguish-fine-fescue-species-mixtures

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2018	YES

Citation

Petrella, D.P., and E. Watkins. 2018. Evaluating shade tolerance among fine fescue species. ASA-CSSA International Meeting, Baltimore, MD. (Poster presentation).

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2018	YES

Citation

Trappe, J.M., F. Sessoms, D.P. Petrella, E. Watkins, and A. Patton. 2018. Identifying and confirming natural weed suppression in fine fescues. ASA-CSSA International Meeting. Baltimore, MD. (Oral presentation)

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2018	YES

Citation

Grimshaw, A.L., H. Y. Qu, P. L. Vines, N. Zhang, W. A. Meyer and S.A. Bonos. 2018. Comparison of Magnaporthiopsis meyeri-festucae isolates by phenotypic turf response. In Agronomy Abstracts. ASA, Madison, WI.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2018	YES

Citation

Chen, H. and J. Murphy. 2018. Wear tolerance of fine fescues in relation to leaf tissue fiber content. ASA-CSSA International Meeting, Baltimore, MD. (Poster presentation)

Accession No. 1013078 **Project No. MIN-21-G11**

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2018	YES

Citation

Chen, H., and J. A. Murphy. 2018. Leaf bruising of fine fescues subjected to wear during three seasons. European Turfgrass Society Conference, July 2018. Manchester, United Kingdom. (Oral presentation)

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2019	YES

Citation

Barnes, M.R. and K.C. Nelson. 2019. Transitions to fine fescues. Web publication. http://lowinputturf.umn.edu/current-research/transitions-fine-fescues

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2019	YES

Citation

Nelson, K.C., H. Ramer, A. Christianson, M. Barnes, A. Meyer, E. Watkins, S. Bonos, B. Horgan, J.A. Murphy, and C. Yue. 2019. Anticipatory governance for sustainable urban public lands: Addressing vegetation management challenges of today and tomorrow. International Symposium on Society and Resource Management (ISSRM), Oshkosh, WI, June 4-7. (Oral presentation)

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2019	YES

Citation

Nelson, K.C., M.R. Barnes, and E. Watkins. 2019. Institutional change the case of sustainable vegetation on college campuses, Environmental Design Research Association (EDRA50), Brooklyn, New York City, New York, May 23-25. (Poster presentation)

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2019	YES

Citation

Jing Luo, Ning Zhang. The rice blast fungus and allied species: A monograph of the fungal order Magnaporthales. Mycological Society of America annual meeting. August, 2019. (Oral presentation)

Other Products

Product Type

Other

Description

Braithwaite, E. 2019. Fine Fescue Patch and Repair Trial. Linn and Benton Country Master Gardener Training and Community Extension Event. Corvallis, OR. September 11, 2019. (Oral presentation)

Product Type
Other

Description
Braithwaite, E. 2019. Fine Fescue Seed Date. Linn and Benton Country Master Gardener Training and Community Extension Event. Corvallis, OR. September 11, 2019. (Oral presentation)

Product Type
Other

Description
Braithwaite, E. 2019. Fine Fescue Seed Date. OSU Turf Field Day. Corvallis, OR. Aug 29, 2019. (Oral presentation)

Product Type
Other

Description
Braithwaite, E. 2019. Fine Fescue Seed Date. School Grounds IPM Field Day. Corvallis, OR. August 20, 2019. (Oral presentation)

Product Type
Other

Description
Braithwaite, E. 2019. Fine Fescue Seed Date and Patch/Repair Trials. Ontario, OR. July 18, 2019. (Oral presentation)

Product Type
Other

Description
Braithwaite, E. 2019. Fine Fescue Seed Date and Patch/Repair Trials. Cove, OR. July 16, 2019. (Oral presentation)

Product Type
Other

Description
Braithwaite, E. 2019. Fine Fescue Seed Date and Patch/Repair Trials. La Grande, OR. Mar 7, 2019. (Oral presentation)

Product Type
Other

Description
Bonos, S. 2019. Fine fescue research. NJ turfgrass field day on July 31, 2019. (Oral presentation)

Product Type
Other

Description
Anderson, N. Conducting large-scale seed production trials on fine fescues. International Herbage Seed Group Workshop, 16 May 2019 Ioka Farm, Silverton, OR. [2019]

Product Type
Other

Description
Anderson, N. Fine Fescue Seed Production Focus Group Meeting, 4 February 2019 Salem, OR. [2019]

Product Type
Other

Description
Anderson, N. Effects of spring mowing and plant growth regulators in fine fescues. International Herbage Seed Group/OSU Industry Field Day, 15 May 2019 Hyslop Research Farm, Corvallis, OR. [2019]

Product Type
Other

Description
Braun, R. Low-input options for grassing Indian lawns. 30 July 2019. Lawn Care Diagnostic Training, West Lafayette, IN. [2019]

Product Type
Other

Description
Braun, R. Fixing Dead Spots: The Number One Reason Homeowners Fire Their Lawn Care Company. 9 July 2019. Turf and Landscape Field Day. West Lafayette, IN. [2019]

Product Type
Other

Description
Braun, R. Performance of Low Input Grasses. 9 July 2019. Turf and Landscape Field Day. West Lafayette, IN. [2019]

Product Type
Other

Description
Braun, R. Consumer preferences in lawn. 10 January 2019. Indiana Green Expo, Indianapolis, IN. [2019]

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Product Type
Other

Description
Watkins, E. 2019. Turfgrass species for low-input lawns in Minnesota. Lawn Water Conservation Workshop. Chaska, MN. September 20.

Product Type
Other

Description
Watkins, E. and B.P. Horgan. Turfgrass research program update. Northern Green. January 16, 2019. Minneapolis, MN.

Product Type
Other

Description
Watkins, E. Fine fescue breeding program update. Grass Seed Production Meeting. February 19, 2019. Roseau, MN.

Product Type
Other

Description
Watkins, E. Improving low-input turfgrass for cold climates. Department of Horticultural Science Seminar. April 24, 2019. St. Paul, MN.

Product Type
Other

Description
Petrella, D. 2019. The weather sucks and so does your grass: strategies for managing harsh weather. Northern Green, Minneapolis, MN. January 15, 2019.

Product Type
Other

Description
Petrella, D. 2019. Improving tolerance to shade in fine fescue turfgrasses. Department of Horticultural Science seminar, St. Paul, MN. February 13, 2019.

Changes/Problems
{Nothing to report}