United States Department of Agriculture

Progress Report

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

Sponsoring Agency	NIFA	**Project Status**	ACTIVE
Funding Source	Non Formula	**Reporting Frequency**	Annual
Accession No.	1013078	**Grants.gov No.**	
		Award No.	2017-51181-27222
Project No.	MIN-21-G11	**Proposal No.**	2017-03196
Project Start Date	09/01/2017	**Project End Date**	08/31/2022
Reporting Period Start Date	09/01/2020	**Reporting Period End Date**	08/31/2021
Submitted By	Ruth Sanborn	**Date Submitted to NIFA**	11/29/2021

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

Project Director

Eric Watkins
612-624-7496
ewatkins@umn.edu

Recipient Organization

REGENTS OF THE UNIVERSITY OF MINNESOTA
200 OAK ST SE # 224
MINNEAPOLIS, MN 554552009
DUNS No. 555917996

Performing Department

Dept of Horticultural Science

Co-Project Directors

Nelson, Kristen
Huang, Bingru
Bonos, Stacy
Bushman, Bradley
Anderson, Nicole
Yue, Chengyan
Shekhar, Shashi
Patton, Aaron

Departments

Agronomy and Plant Genetics
Plant Biology and Pathology
{NO DATA ENTERED}
of Hort Science
Computer Sci and Engineering
Horticulture and Landscape Architecture

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?

Objective 1: Identifying barriers for homeowners and public land managers

The consumer survey data were fully analyzed and used to write two manuscripts, one of which has been published. We also developed a survey that is being distributed to grass seed producers in multiple states. The Objective 1.3 team set up new contacts, theoretical constructs, and extended six-year funding with an NSF Urban LTER in Minnesota. We supported the development of outreach materials and included a yard nutrient management project and a low-input lawn project in the Fall 2021 senior capstone course. Under Dr. Nelson's supervision, two out of ten senior capstone student groups worked with Hopkins, MN planners and land managers on projects that incorporated low-input fine fescue varieties in right-of-way vegetation and bee lawns.

Objective 2: Breeding and Genetics

A PacBio CLR sequence-based genome was assembled as a reference for final association studies, it is large and cumbersome, and new approaches are needed. Genetic variation of heat tolerance in hard fescue was examined for 240 lines in growth chamber studies at 30/ 25 °C (day/night)) for 35 days. Results showed significant genetic variability in hard fescue for heat tolerance. Progenies of a mapping population were visually rated on a scale of 1 to 10 in the years 2018, 2019, 2020, and 2021 for the summer patch. Next Generation Sequencing was performed, and the sequence data were analyzed by Stacks to find SNP markers. We obtained 7800 SNPs shared by 90% of samples using the reference genome involved. The genetic markers were put in JoinMap 4.1 and a linkage map with 21 linkage groups was constructed. We also finalized the protocol for transcriptome analysis of summer patch tolerance in hard fescue. Turfgrass breeders in New Jersey screened 3,936 hard fescue clones for summer patch tolerance and selected 150 clones with improved tolerance to the disease. In Minnesota, continued work has refined recommendations for controlled environment shade screening methodology using layered photoselective filters.

Objective 3: Biology Research to Support Breeding Efforts

Our pathology team initiated a snow mold screening of hard fescue genotypes from public breeding programs and public collections. In New Jersey, project participants isolated 14 fungal strains from seven fine fescue samples exhibiting symptoms of summer patch disease in Massachusetts and New Jersey. Among them, eight isolates were sequenced and identified as Magnaporthiopsis meyeri-festucae, M. poae, and M. incrustans. We also developed a culture-independent, TaqMan real-time PCR assay for M. meyeri-festucae.

Objective 4: Information delivery

We created and designed a relational database for the national turfgrass evaluation program, namely, NTEP-DB 1.0, and published the work in a peer reviewed journal. NTEP-DB 1.0 reduced manual efforts and required expert knowledge to extract meaningful information. However, the existing NTEP data lacks explicit spatial information (e.g., geo-coordinates, elevation), which hinders the use of advanced spatial data mining techniques such as disease or stress hotspot detection and predicting turf quality ratings. To this end, we leveraged the publicly available Lidar dataset from Minnesota Geospatial Commons to

investigate if turf quality ratings could be explained via the elevation information. Elevation data also enabled us to explore additional spatial information, including flow direction and water accumulation in this context.

Objective 5: Identifying Solutions

Data collection continued or concluded in three field experiments in IN, MN, and OR, with the objectives to determine optimal fertility programs during establishment, quantify maintenance inputs, compare new and old cultivars, and quantify mowing requirements of cool-season turf species. The seed production team focused on data analysis of the two multi-year research projects. Statistical analysis has been completed and manuscript drafts have been written. Data from this work is being used to secure a chlormequat chloride product (Adjust) registration on grasses grown for seed in Oregon, including fine fescues. A third year of data (turf quality, density and color) were collected from two field trials: one trial assessed soil pH and the second trial N fertilizer source effects. Pathogenic isolates of M. poae and M. festuca-meyeri were inoculated into these field trials in June 2021.

Objective 6: Quantifying Benefits and Informing the Public

Research audiences were reached through numerous peer reviewed publications. Six extension publications were finalized and are in-press. Accounts under the name of "LowInputTurf" across multiple social media platforms continued to inform and educate the public, and earned 112,200 impressions on Twitter and 2,580 impressions on Pinterest during the last reporting period.

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 virtual field days at participating institutions. These field days were viewed 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?

Objective 1: Identifying barriers for homeowners and public land managers

An online turfgrass seed producer survey will be distributed and data will be collected and analyzed. We will also explore institutions that serve diverse communities in the Minneapolis-St. Paul metropolitan area, including churches, health care facilities, schools, and businesses. Many institutions own buildings surrounded by turf areas. Like homeowners, they seek out sustainable practices that match their values for serving people and the environment. Also, institutions are critical nodes in networks with members, clients, and customers coming and going daily. Current scholarship is limited in the ability to speak to practice over time and across economically and ethnically/racially diverse communities.

Objective 2: Breeding and genetics

A new circular consensus sequencing-based PacBio assembly of hard fescue will be completed along with association analyses. We will perform gene module-trait association analysis to determine potential gene networks or hubs linked to physiological traits of heat tolerance. Team members will finalize the linkage map and mapping of summer patch resistant related Quantitative Trait Loci (QTL) in hard fescue. Finally, we will implement larger scale screening of fine fescues for foliar shade tolerance using a layered photoselective filter approach developed as part of this project.

Objective 3: Biology research to support breeding efforts

We will continue to conduct a snow mold screen of fine fescue plantings in the growth chamber using the fungi Typhula incarnata/ishikariensis. We also plan to use the summer patch assay for pathogen detection and quantification, and continue summer patch pathogen collection, pathogenicity test, and inoculation work. An ongoing study evaluating the effects of soil pH and nitrogen fertilizer source on summer patch incidence in fine fescues will be completed and analyzed.

Objective 4: Information delivery

We will continue to explore new approaches to analyzing and understanding turfgrass field trials. Elevation data cannot solely support a simple way to directly understand the correlation between the elevation and turfgrass quality ratings. To this end, other newly added spatial information (e.g., flow direction and water accumulation) will allow us to identify depressions within the study area and compare quality ratings according to those depressions. In addition, flow accumulation will reduce the search space to identify cultivars that are sensitive/robust to elevation variation within the experimental site. The new spatial data only cover experimental sites in Minnesota, but we plan to expand this information to additional sites in the program.

Objective 5: Identifying solutions

A multi-state field experiment on fine fescue turfgrass management concluded in summer 2021 and two more experiments will be concluding in autumn of 2021. Data will be analyzed and a manuscript will be submitted for publication.

Objective 6: Quantifying benefits and informing the public
A master PowerPoint presentation and videos accompanying the extension publications will be disseminated among collaborators to edit, use, and share with county and regional extension educators for use in consumer and professional education. We will continue to write and post blog articles on our project website <https://lowinputturf.umn.edu/>.

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	2.5	0	0	0	2.5
Professional	1.7	0	3.5	0.2	5.4
Technical	0	1.4	0	0	1.4
Administrative	0	0	0	0	0
Other	0	0	0	0	0
Computed Total	4.2	1.4	3.5	0.2	9.3

Student Count by Classification of Instructional Programs (CIP) Code

Undergraduate	Graduate	Post-Doctorate	CIP Code
	1		11.07 Computer Science.
	4		45.06 Economics.
7	2	1	01.11 Plant Sciences.

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

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

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2020	YES

Citation

Barnes, M. 2020. Working across boundaries: The importance of transdisciplinary turf research https://lowinputturf.umn.edu/working-across-boundaries-importance-transdisciplinary-turf-research

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2020	YES

Citation

Braun, R.C., A.J. Patton, E. Watkins, P. Koch, N.P. Anderson, S.A. Bonos, and L.A. Brilman. 2020. Recommended taxonomic classifications of fine fescue taxa used in turfgrass systems. Abstract 128127 of the ASA, CSSA and SSSA International Meetings, online.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2021	YES

Citation

Braun, R.C., A.J. Patton, E. Watkins, A.B. Hollman, J.A. Murphy, B.S. Park, A.R. Kowalewski, and E.T. Braithwaite. 2021. Optimal fine fescue mixture seeding dates in the northern United States. Agronomy Journal, 113, 4413–4428. https://doi.org/10.1002/agj2.20859

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2020	YES

Citation

Braun, R.C., A.J. Patton, E.T. Braithwaite, and A.R. Kowalewski. 2020. Establishment of Low-Input Turfgrass from Seed Using Patch and Repair Mixtures: Mulch and Starter Fertilizer Effects. Crop Science. 2020:1-15. http://dx.doi.org/10.1002/csc2.20266

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2021	YES

Citation

Breuillin Sessoms, F., D.P. Petrella, J.M. Trappe, N.T. Mihelich, A.J. Patton, and E. Watkins. 2021. Field evaluation of weed suppression in fine fescue (Festuca spp.). Crop Science 61(4):2812-2826. https://doi.org/10.1002/csc2.20506

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2021	YES

Citation

Chapman C. and B. Huang. 2021. Genotypic variation in heat tolerance and post-stress recovery for hard fescue https://lowinputturf.umn.edu/genotypic-variation-heat-tolerance-and-post-stress-recovery-hard-fescue

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2020	YES

Citation

Chen, H., B.S. Park, and J.A. Murphy. 2020. Traffic form and season of wear affect responses of fine fescues. Agron. J. 113:3778-3788. https://doi.org/10.1002/agj2.20563

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

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Submitted	2021	YES

Citation

Chou, MY., Luo, J., Clarke, B.B., Murphy, J.A., Zhang, N., Vines, P.L., Koch, P.L. Rapid detection of the recently identified turfgrass pathogen Magnaportheopsis meyeri-festucae using recombinase polymerase amplification. Submitted to Plant Disease in August, 2021.

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2021	YES

Citation

Koch. P. 2021. When it comes to snow mold, fine fescue is the choice
https://lowinputturf.umn.edu/when-it-comes-snow-mold-fine-fescue-choice

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2021	YES

Citation

Kowalewski, A. and E. Braithwaite. 2021. Fine fescue and the National Turfgrass Evaluation Program
https://lowinputturf.umn.edu/fine-fescue-and-national-turfgrass-evaluation-program

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Under Review	2021	YES

Citation

Lai, Y., C. Yue, E. Watkins, A. Patton and R. Braun. 2021. A Behavioral Approach to Identify Barriers to Adoption of New Technology: A Case Study of Low-input Turfgrasses. Under review by Agricultural Economics.

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2021	YES

Citation

Luo, J. and N. Zhang. 2021. Two common summer patch pathogens on fine fescues
https://lowinputturf.umn.edu/two-common-summer-patch-pathogens-fine-fescues

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2021	YES

Citation

Moncada, K. 2021. Other fine fescue research at the University of Minnesota: Bee lawns
https://lowinputturf.umn.edu/other-fine-fescue-research-university-minnesota-bee-lawns

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2020	YES

Citation

Petrella, D.P. and E. Watkins. 2020. Variation in fine fescue taxa response to simulated foliar shade. Crop Science 60(6):3377-3394. https://doi.org/10.1002/csc2.20279

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

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2021	YES

Citation

Qiu, Y., Y. Yang, C.D. Hirsch, and E. Watkins. 2021. Building a reference transcriptome for the hexaploid hard fescue turfgrass (Festuca brevipila) using a combination of PacBio Isoseq and Illumina sequencing. Crop Science 61(4):2798-2811. https://doi.org/10.1002/csc2.20489

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2020	YES

Citation

Wu, D.S., A.L. Grimshaw, H.Y. Qu, P.L. Vines, E. N. Weibel, W.A. Meyer and S.A. Bonos. 2020. Inheritance of summer patch disease resistance in hard fescue. In Agronomy Abstracts, ASA, CSSA, SSSA Annual Meeting Nov. 7-9, 2020 (Virtual Meeting).

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2021	YES

Citation

Wu, S., A. L. Grimshaw, Y. Qu, P. L. Vines, E. N. Weibel, W. A. Meyer, and S. A. Bonos. 2021. Inheritance of summer patch disease resistance in hard fescue (Festuca brevipila Tracey). p.46. In Proceedings of the 29th Rutgers Turfgrass Symposium. March 18, 2021 (Virtual Meeting).

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Accepted	2021	YES

Citation

Xie, Y., M. Farhadloo, N. Guo, S. Shekhar, E. Watkins, L. Kne, H. Bao, A. J. Patton, and K. Morris. "NTEP?DB 1.0: A relational database for the national turfgrass evaluation program." International Turfgrass Society Research Journal, Accepted on May 5th, 2021, DOI: 10.1002/its2.76.

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Under Review	2021	YES

Citation

Xu, Y., S. Rossi, and B. Huang. 2021. Comparative transcriptomics and gene network analysis revealed secondary metabolism as preeminent metabolic pathways for heat tolerance in hard fescue. Grass Research (submitted and in review).

Type	Status	Year Published	NIFA Support Acknowledged
Websites	Published	2021	YES

Citation

Yue, C., M. Cui, E. Watkins and A. Patton. 2021. What factors influence consumer adoption of low-input turfgrasses? https://lowinputturf.umn.edu/what-factors-influence-consumer-adoption-low-input-turfgrasses

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2021	YES

Citation

Yue, C., M. Cui, E. Watkins, and A. Patton. 2021. Investigating Factors Influencing Consumer Adoption of Low-input Turfgrasses. HortScience 56 (10), 1213-1220.

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

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2021	YES

Citation

Yue, C., M. Cui, E. Watkins, and A. Patton. 2021. Investigating Factors Impacting Consumer Adoption of Low-Input Turfgrasses. Presentation at American Society of Horticultural Science 2021 annual conference.

Other Products

Product Type

Other

Description

Anderson, N.P. 2021. Non-Thermal: PGRs, Spring Mowing and Nitrogen Fertility. OSU Fine Fescue Field Day. Silverton, OR.

Product Type

Audio or Video

Description

Bonos, S. 2020. Video: Fine Fescue Breeding from Rutgers University
https://lowinputturf.umn.edu/video-fine-fescue-breeding-rutgers-university

Product Type

Audio or Video

Description

Braun, R. 2020. Video: Research Updates from Purdue University
https://lowinputturf.umn.edu/video-research-updates-purdue-university

Product Type

Educational Aids or Curricula

Description

Braun, R. Managing minimal-to-no mow areas on the golf course. Turf and Landscape Seminar. Online. [2020].

Product Type

Other

Description

Braun, R.C., A.J. Patton, E. Watkins, P. Koch, N.P. Anderson, S.A. Bonos, and L.A. Brilman. 2020. Use of fine fescues on golf courses: IV. Biotic stresses. Golf Course Management. September, p.82-87. https://lsc-pagepro.mydigitalpublication.com/publication/?m=61389&i=670551&p=86

Product Type

Audio or Video

Description

Kowalewski, A. and E. Braithwaite. 2020. Video: Low-Input Turfgrass Using Fine Fescues from Oregon State University
https://lowinputturf.umn.edu/video-low-input-turfgrass-using-fine-fescues-oregon-state-university

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

Product Type

Audio or Video

Description

Park, B. 2020. Video: Optimal Seeding Timings for Fineleaf Fescue from Rutgers University
https://lowinputturf.umn.edu/video-optimal-seeding-timings-fineleaf-fescue-rutgers-university

Product Type

Audio or Video

Description

Patton, A. and R. Braun. 2021. Video: Identification Tips for Fine Fescues
https://lowinputturf.umn.edu/video-identification-tips-fine-fescues

Product Type

Other

Description

Petrella, D. and E. Watkins. 2021. Fine fescues vs. foliar shade. In the July 21 edition of GCM magazine online.
https://www.gcmonline.com/latest-stories/fine-fescue-shade-tolerance

Changes/Problems

{Nothing to report}