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**	08/31/2021
Reporting Period Start Date	09/01/2017	**Reporting Period End Date**	08/31/2018
Submitted By		**Date Submitted to NIFA**	

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

Project Director

Eric Watkins
612-624-7596
ewatkins@umn.edu

Recipient Organization

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

Performing Department

Horticultural Science

Co-Project Directors

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

Departments

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

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?

Our project is based on stakeholder interest in lower-input turfgrasses to provide functional turf areas while reducing inputs of water, fertilizer, mowing, and pesticides. Our long-term objective is to increase the use of fine fescues for sustainable landscapes. In the first year of our project, we have made much progress in addressing our objectives of identifying barriers that are preventing stakeholders from using fine fescues, finding innovative solutions to these barriers, and developing cultivars that fulfill their desires.

In Objective 1, we collaborated with college and university Sustainability Offices and Facilities Management Offices to develop fine fescue demonstration plot sites at universities in seven states. Signs at each site direct passers-by to more information at lowinputturf.umn.edu. We completed six focus groups with public land managers in Indiana, Oregon, and New Jersey related to fine fescue implementation on public lands and began interviews at partner institutions with individuals involved in turf decision making on their respective campuses. We have also drafted a consumer survey focused on conversion of lawns to low-input species that will be distributed in spring 2019.

In Objective 2, we have been focused on genetic improvement of fine fescue species. Researchers at Rutgers University established a hard fescue summer patch heritability study in two locations that was inoculated with both M. meyeri-festucae and M. poae in the summer of 2018. In addition, hard fescue and strong creeping red fescue genotypes have been identified that contrast in response to wear tolerance and crossed in a diallel scheme. Progeny derived from these crosses will be evaluated for wear tolerance traits. Also at Rutgers, members of our team studied differential physiological performances for hard fescue cultivars 'Reliant IV' and 'Predator'. They found that 'Reliant IV' began to show improved heat tolerance and this response was related to significantly higher chlorophyll content, better photosynthetic efficiency, and lower electrolyte leakage. Total RNA from leaf samples of both 'Reliant IV' and 'Predator' at 0, 7, and 14 d of heat stress was extracted and sent for RNA-seq analysis using Illumina HiSeq platform. At the University of Wisconsin, we are testing inoculation methods for Typhula fungi to use in screening large numbers of fine fescue plants for Typhula resistance. We found that placing a sterile rye grain infested with either Typhula fungi and growing for 4 weeks at a constant temperature of 4 degrees C was the most effective inoculation method relative to the other treatments tested. At the University of Minnesota, we have confirmed fine fescue-mediated weed suppression against crabgrass in both field and growth chamber experiments. We have also determined optimal nitrogen and phosphorus levels for future bioassays on allelopathy in the fine fescues. We have begun sequencing a hard fescue genotype for the development of a reference genome that will allow for more rapid improvement of important traits. We have also begun to assemble an association population of diverse hard fescue genotypes; phenotyping of this panel will be done using various methods developed as part of this grant.

Objective 3 is focused on the biology of summer patch disease. We isolated 183 fungal strains from 30 fine fescue samples that showed summer patch-like symptoms to determine the biogeography and pathogenicity of this pathogen. These samples were collected from CA, OR, IN, MA, MN, and NJ. Based on DNA barcoding, 29 isolates from NJ and MA were identified as Magnaporthiopsis meyeri-festucae, the recently described pathogen that causes root infection of fine fescue. The fungal cultures will be used for inoculation experiments in the field. We have also initiated field and growth chamber studies to further our understanding of this disease. In the field, soil pH amendments were applied to main plots and two hard fescue cultivars were seeded as subplots in a field trial to assess the influence of pH on disease severity; a second trial is assessing the impact of nitrogen sources on disease severity. A growth chamber study was initiated to evaluate the relative pathogenicity of

Magnaporthiopsis spp. [M. meyeri-festucae (22 isolates), M. poae (1 isolate), M. incrustans (10 isolates), M. cynodontis (3 isolates), M. taurocanis (5 isolates)], and used to select pathogenic isolates for other experiments.

In Objective 4, we are working to increase the accessibility of turfgrass evaluation data on fine fescues for consumers. To guide database design, we created a web-based Qualtrics survey with 24 detailed questions to ask for desired uses and functionalities from various user groups (e.g., researchers, managers, home owners). Over 300 responses were received. As the first step in developing the Relational DataBase Management Systems, we gathered current National Turfgrass Evaluation Program data and transformed them into a single relational database table (i.e., with over 10,000 rows and 100 attributes). We designed a working prototype of the database (i.e., a conceptual Entity-Relationship diagram and a set of normalized database tables).

In Objective 5 we are developing fine fescue best management practices for both managed turf and seed production systems. We established turf field experiments in IN, MN, OR, NJ, and CT to identify solutions to management and establishment barriers. Objectives of these field experiments include determining optimal seeding time of the year, quantifying maintenance inputs, comparing new and improved to old cultivars, and quantifying mowing requirements of fine fescues compared to other turf species. For seed production, we assembled a focus group of Oregon fine fescue seed producers and held two meetings to gather input on research goals. Based on focus group input, four on-farm trials were conducted to evaluate nitrogen by plant growth regulator interactions on seed yield and seed yield components in first year creeping red fescue and Chewings fescue fields in the absence of field burning. A new trial was planted in spring 2018 in Oregon to evaluate the effects of spring mowing on head emergence, above ground biomass, and seed yield.

As part of Objective 6, we drafted a literature review of the fine fescue species that includes their improvement, production, establishment and management barriers. Social media accounts under the name of "LowInputTurf" have been created across multiple platforms to inform and educate the public. Since May 2018, our tweets have earned 65,200 impressions on Twitter, and our Pinterest account has an average of 108 monthly viewers.

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

{Nothing to report}

How have the results been disseminated to communities of interest?

We have disseminated results from the first year of this project to stakeholders through talks at professional conferences and presentations at field days. We have communicated results to the scientific community through scientific journal papers and presentations at scientific conferences. We have also posted updates on university turfgrass science websites to reach a wider lay audience. We have also posted updates on social media to reach a wider lay audience. Accounts under the name of "LowInputTurf" have been created across multiple social media platforms to inform and educate the public. Since 1 May 2018, our tweets have earned 65,200 impressions on Twitter, and the Pinterest account has an average of 108 monthly viewers.

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

For the work on identifying barriers for homeowners and public land managers, we will finalize both the consumer survey and the producer survey for distribution to our target audience, and develop economic models based on the results (Objectives 1.1 and 1.2). Important parameters we hope to measure include what are the reasonable investments that consumers will make to re-do their lawns with low-input grasses and what kinds of savings consumers might expect over time if they converted to low-input grasses. For Objectives 1.3 and 1.4, we will complete the remaining focus groups, interviews, and subsequent transcriptions. Remaining interviews will include institutional representatives from the University of Wisconsin, Utah State, and University of Minnesota. We will analyze and prepare both a practical document for the collaborators on this grant, as well as a journal article focused on higher education institution transitions to fine fescues on campuses. Outputs from this objective will also include a combined curriculum and research toolkit for undergraduate students to be distributed to partner institutions to engage students with the fine fescue demonstration plots planted in the previous grant period.

The breeding and genetics projects in Objective 2 are at different stages of development and will take different approaches. For the summer patch heritability study, a second year of summer patch evaluation will be conducted in 2019. Another trial will be established and inoculated with both pathogens in the spring of 2019. We hope to determine narrow-sense heritability of summer patch resistance from two years of data. Because we now know the reaction of the crosses to summer patch disease, a population will be genotyped using Genotyped by Sequencing (GBS) sequencing 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. We will continue RNA-seq analysis of leaf transcriptome for 'Reliant IV' and 'Predator' under heat stress. We will perform annotation of sequences identified from both cultivars and the analysis of GO term and KEGG

pathways. Fine fescue genotypes sampled in NJ and MN will have biomass and fiber composition quantified for the wear stress part of this objective. Snow mold screening of breeding material will commence once methods are tested and confirmed for both Microdochium patch and Typhula blight. We will continue to conduct bioassays to better understand allelopathy in Chewings fescue and confirm the compound(s) responsible for the observed response; this work will eventually lead to more useful screening methods. We will continue to evaluate fine fescue turfgrass breeding plots for other diseases that have historically been seen on lower-input turfgrasses including dollar spot (caused by Sclerotinia homoeocarpa), red thread (caused by Laetisaria fuciformis), and leaf spot (caused by Bipolaris, Drechslera, and Exserohilum spp.).

For Objective 3, we will continue collecting, isolating and identifying summer patch pathogen for fine fescues from a broad geographical area in North America. The fungal strains will be used for pathogenicity and virulence evaluation, and the most virulent ones 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. Pathogenic isolates identified in growth chamber study for relative pathogenicity will be used to select for field experiments to support breeding efforts. Hard fescue subplots in the soil pH trial will be inoculated with pathogenic isolates and monitored for summer patch severity. Similarly, pathogenic isolates will be inoculated into the nitrogen source trial on 'Predator' hard fescue and monitored for disease severity.

For Objective 4, we are analyzing user needs and preferences based on survey responses. We will advance our prototype design of the database and the data will then be reformatted into the refined database. The database will be validated against the desired queries of users to test if the queries are feasible based on the database design and if the time cost of the queries are acceptable. Upon successful validation, the database will be moved from local machines to production servers. The next step will be the web-application building process to provide on-demand turfgrass seed recommendations with minimal user input.

As part of Objective 5, we will continue the field research on turf best management practices at of fine fescues in turfgrass evaluations and collect and analyze data from the three field experiments. A fourth field experiment investigating home lawn renovation barriers with fine fescues will be established in fall 2019 in multiple states. This research is helping us identify solutions to three barriers - sod availability, lawn conversion practices, and post-establishment management - to consumer adoption of fine fescues. For the work to increase fine fescue seed production, we will hold focus group meetings to continue receiving input from the fine fescue seed industry. The second year of the nitrogen by plant growth regulator interaction trials will be conducted on four second year commercial fine fescue fields. We will carry out a spring mowing trial on creeping red fescue and Chewings fescue to evaluate the effects of early clipping on head emergence timing, above ground biomass, and seed yield. On-farm trials will be displayed at a field tour associated with the International Herbage Seed Group Conference. Spring mowing trials will be part of OSU's Hyslop Field Day.

For Objective 6, which focuses on informing the public on fine fescue benefits, we will first publish the literature review on fine fescues that will address gaps in knowledge of previous research. We will create a master PowerPoint presentation on the installation and care of low-input fine fescue with an end goal to be shared with county and regional extension educators, as well as turf scientists for use in consumer and professional education. Our outreach efforts via social media will continue to communicate the benefits of fine fescues to our target audience.

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	1.4	0	1.6	3.9	6.9
Professional	0	0	0	0	0
Technical	1.9	3	0	0	4.9
Administrative	0	0	0	0	0
Other	0	0	0	0	0
Computed Total	3.3	3	1.6	3.9	11.8

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

Student Count by Classification of Instructional Programs (CIP) Code

Undergraduate	Graduate	Post-Doctorate	CIP Code
6	1	5	01.06 Applied Horticulture and Horticultural Business Services.
0	1	2	45.11 Sociology.
0	1	0	52.14 Marketing.
0	0	1	11.07 Computer Science.

Target Audience

Presentations were given at field days in Minnesota, Oregon, Indiana, and New Jersey. 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 Northern Green in Minneapolis and at the Grass Seed Institute in Roseau, MN. Students in undergraduate courses were also presented with results from this work during lecture and discussion sessions focused on sustainable turfgrass management.

Products

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

Citation

Barnes, M.R., K.C. Nelson, A. Meyer, E. Watkins, S. Bonos, B. Horgan, W. Meyer, J. Murphy, and C. Yue. 2018. Public land managers and sustainable urban vegetation: The case of low-input turfgrasses. Urban Forestry & Urban Greening 29:284-292.

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

Citation

Grimshaw, A.L., Qu, Y., Meyer, W.A., Watkins, E. and Bonos, S.A., 2018. Heritability of simulated wear and traffic tolerance in three fine fescue species. HortScience 53(4):416-420.

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

Citation

Grimshaw, A., J. Luo, P.L. Vines, L. Hoffman, S.A. Bonos, B.B. Clarke, J.A. Murphy, W. A. Meyer, and N. Zhang. 2018. Evaluation of pathogenicity of a newly discovered summer patch causal organism. p.29. In Proceedings of the 27th Rutgers Turfgrass Symposium. January 12, 2018.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2017	YES

Citation

Grimshaw, A.L., J. Lou, P. Vines, L. Hoffman, N. Zhang, B.B. Clarke, S. Bonos and W. A. Meyer. 2017. Evaluation of pathogenicity for a newly discovered summer patch causal pathogen. In Agronomy Abstracts. ASA, Madison, WI.

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

Type	Status	Year Published	NIFA Support Acknowledged
Journal Articles	Published	2017	YES

Citation

Luo J., P.L. Vines, A. Grimshaw, L. Hoffman, E. Walsh, S. Bonos, B.B. Clarke, J.A. Murphy, W.A. Meyer, and N. Zhang. 2017. Magnaporthiopsis meyeri-festucae sp. nov. associated with a summer patch-like disease of fine fescue turfgrasses. Mycologia 109:780-789. DOI: http://dx.doi.org/10.1080/00275514.2017.1400306.

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

Citation

Luo, J., P.L. Vines, A. Grimshaw, L. Hoffman, E. Walsh, S.A. Bonos, B.B. Clarke, J.A. Murphy, W.A. Meyer, and N. Zhang. 2018. Novel Magnaporthales fungi pathogenic to switchgrass and turfgrasses. International Congress of Plant Pathology. Boston, USA, July 31, 2018, poster.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2017	YES

Citation

Mercer-Taylor, B., K.C. Nelson, M. Barnes, and S. Helle. 2017. How could the grass on your campus be as ‘green’ as it looks? Upper Midwest Association for Campus Sustainability (UMACS), Central College, Pella, Iowa, October 5, poster.

Type	Status	Year Published	NIFA Support Acknowledged
Conference Papers and	Published	2017	YES

Citation

Schultz, L., K.C. Nelson, M. Barnes, and S. Helle. 2017. How could the grass on your campus be as ‘green’ as it looks? Association of American Sustainability in Higher Education (AASHE), San Antonio, Texas, October 15-18, poster.

Other Products

Product Type

Other

Description

Anderson, N.P. Nitrogen and Plant Growth Regulator Fine Fescue Seed Crop Plot Tour. Ioka Farms, Silverton, OR. [2018]

Product Type

Other

Description

Anderson, N.P. Fine Fescue Seed Production Focus Group Meeting, 9 February 2018, Sublimity, OR. [2018]

Product Type

Other

Description

Anderson, N.P. Fine Fescue Seed Production Focus Group Meeting, 29 November 2017, Sublimity, OR. [2017]

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

Product Type

Other

Description

Braun, R. What are fine fescues and how can you use them? Lawn Care Diagnostic Training, 26 July 2018. W.H. Daniel Turfgrass Research Diagnostic Center, West Lafayette, IN. [2018]

Product Type

Other

Description

Watkins, E and B. Horgan. Turf and Grounds Field Day, 9 August 2018. Turfgrass Research and Outreach Center, St. Paul, MN. [2018]

Product Type

Other

Description

Watkins, E. Expanding fine fescue seed production to meet consumer needs. Grass Seed Institute. Roseau, MN. [2018]

Changes/Problems

{Nothing to report}