NATIONAL EVALUATION OF COOL-SEASON TURFGRASS WATER USE AND DROUGHT RESISTANCE

Annual Progress Report – May 31, 2019
Washington Turfgrass Seed Commission

ABSTRACT

This is an exciting new project that evaluates, through a nationwide trial, Kentucky bluegrass and tall fescue for their water use and drought resistance. Data generated from this project will be used to identify, label and certify low-water using cool-season grass cultivars for use on lawns, parks, athletic fields and golf courses. We were awarded $35,000 per year for three years ($105,000 total) to help with the funding of this project.

Kevin Morris, NTEP and Dr. Michael Kenna, USGA

BACKGROUND AND UPDATE

As discussed at previous WTSC meetings, the United States Golf Association (USGA) budgeted considerable funding to conduct a national water use and drought tolerance trial, utilizing the National Turfgrass Evaluation Program (NTEP) as its evaluation organization. USGA funded the building of rainout shelters and irrigation infrastructure at several locations, and is working with NTEP in determining testing protocols, data collection methods, etc. Besides data collection on water use and drought resistance parameters, the goal of this effort is for the EPA Water Sense program to adopt these (or similar methods) and to agree to certify the first plant species with the Water Sense label. USGA has become a Water Sense partner and we have talked to the Water Sense staff about certifying grasses. EPA is very interested in the concept (they have never certified a plant or plants as water saving) as USGA Green Section Research Director Dr. Mike Kenna and I have met with them to discuss collaborative efforts. However, EPA needs to see more about the methods and tests, as well as we believe, some successful trials. Also, they will need our help in solving some legal requirements when certifying a product (could be unique for plants, however). Attachment A is our proposal that was submitted to WTSC and chosen for funding.

Because of space limitations (only around 30-35 entries can be accommodated), we limited the trial to only Kentucky bluegrass and tall fescue. We chose tall fescue over perennial ryegrass because of more interest from seed companies in submitting entries (than perennial ryegrass). Fortunately, when our deadline passed, we had received 32 entries (14 bluegrass, 18 tall fescue). We added three standards to the trial (one each of Ky. Bluegrass, tall fescue and perennial ryegrass). See Attachment C for the list of entries and sponsors.

Most locations planted the trial in fall 2016, while a few had to wait on infrastructure improvements (mostly irrigation), and therefore will plant in spring 2017. Planting plans were developed for both Approach 1 and 2 sites. Drought treatments were initiated in 2017 on those locations with mature plots.

Rainout shelters were ordered and delivered in spring 2017 to each of the five Approach 1 sites. Installation was performed by staff at each site. As a part of the grant agreement, NTEP returned a portion of the funding allocated for rainout shelter purchases back to each researcher to help with installation and other initial expenses. Approach 2 sites received $15,000 initial set-up costs for irrigation installation and/or other expenses.

After the initial development of protocols, we have continued to meet with our cooperators to examine and tweak these protocols. This process is ongoing as we see what works, and what does not work, making additional changes to procedures, if necessary in the future.

The cost to run each trial location is high, and only a portion of that is covered by USGA's donation ($250,000). Therefore, we sincerely appreciate the support received from WTSC for the initiation of this trial. Without your support, this trial would not be conducted.

PROGRESS REPORT – MAY 2019

The first data from the cool-season trial was collected in 2017 at six of the ten locations. Four Approach 1 (shelter) locations collected data during a 100-day induced drought period, and in some cases, large differences were noted in amount of water used by entries, however very little statistical differences were noted among entries. For 2018, we changed the re-watering procedures threshold to 65% green cover, as well as expanded our statistical analysis for all sites to include separate Kentucky bluegrass and tall fescue tables. In 2018, all ten sites collected data.

APPROACH 1

Rain exclusion shelters are used to simulate 100-day drought periods in higher rainfall regions. Under the rain exclusion shelters we measured the amount of water needed to maintain 65% green cover (changed from 50% in 2017), rate turfgrass quality as well as evaluate recovery from drought when irrigation is resumed.

Irrigation amounts needed to maintain 65% green cover varied significantly among entries, and in some cases was more than double the best entry. However, the changes made to our re-watering threshold, as well as our statistical analysis resulted in virtually no statistical differences at Griffin, GA, Amherst, MA and Fayetteville, AR, even though in some instances large differences in amount of water used were evident (range = 4.3 to 72 mm). At College Park, MD statistical differences were noted, mainly among the Kentucky bluegrass entries, with 'BAR PP 110358', 'PST-KS-13-141', Blue Devil', 'NAI-13-14' and 'NAI-13-132' the top entries. 'BAR PP 110258' used less water than many of the tall fescue entries (169.3 mm). Tall fescues using the least water at College Park, MD (156.7 – 1.69.3 mm) include 'RS4', 'Catalyst', 'Monet', 'LTP-SYN-A3' and 'Titanium LS'.

The greatest entry separation in any Approach 1 (shelter) site was noted at West Lafayette, IN. Like most sites, the tall fescues, in general, needed less water to remain green than most bluegrasses. However, at West Lafayette there is a great range of performance, from 161 – 317.7 mm for tall entries, 216 – 313.7 mm for Kentucky bluegrass. Tall fescues with the least water required at this site in 2018 include 'DLFPS-321/3678' (161 mm), 'DLFPS-321/3677' (173.7 mm) and 'RS4' (175.7 mm). For bluegrass at West Lafayette, 'Barrari' (216 mm), 'NAI-13-132' (216.3 mm) and 'NAI-13-14' (228.7 mm) used the least water in 2018.

APPROACH 2

The drier climate ET_o-based sites evaluate performance at three deficit irrigation levels for 100-120 day periods. Data recorded includes percent green cover over time, turfgrass quality and recovery rate after sufficient irrigation is applied. The ET_o-based locations allow us to determine the minimum level of deficit irrigation appropriate for, and thus the water savings from each entry. It was determined that 80, 60 and 40% ET_o replacement levels would be utilized again in 2018, except for the St. Paul, MN site which would utilize 0, 25 and 75% ET_o replacement (due to its far northern location).

In 2017, only Approach 2 sites at Riverside, CA and Las Cruces, NM collected data. In 2018, all five sites collected data, with four locations (Riverside, Las Cruces, Fort Collins, CO and Logan, UT) running irrigation at 40, 60 and 80% ET_o replacement and St. Paul, MN using 0, 25 and 75% ET_o replacement, while adjusting for any rainfall received during the 120 day drought period.

At Riverside, the 40% ET_o irrigation regime was very harsh on all entries, with no entry delivering even acceptable lawn turf quality ratings (6.0+) throughout the drought period, or even minimally acceptable turf quality ratings (5.0) 60 days into the drought period. Turf quality ratings averaged over the entire season at 40% ET_o replacement showed all entries with 5.0 score or higher. The 60% ET_o replacement regime did not show a single entry with an acceptable mean turf quality rating (6.0) at end of the season, including recovery time. The 60% regimes did show some statistical significance among some Kentucky bluegrass entries, but not tall fescue. The 80% ET_o regime, which is considered adequate replacement of ET lost for cool-season grasses, did some show entries with acceptable turf quality averages, but with no statistical difference among Kentucky bluegrass or tall fescue entries.

The Las Cruces, NM site, while being hot during summer, is not quite as harsh as Riverside (maybe due to some summer rains), which elevated some quality ratings to acceptable levels. Statistical significance was only noted between the top bluegrass entry ('PST-K11-118') and the lowest entry ('Midnight') at 40% ET_o. No statistical significance was seen at the 60% level, while several entries performed statistically better at the least harsh, 80% ET_o. Statistical significance among tall fescue was not seen at the 40% and 60% ET levels, but was noted at the 80% level. At the 80% ET_o level, the top performing Kentucky bluegrasses were 'NAI-13-14', 'NAI-13-132', 'Blue Devil' and 'Midnight'; the top tall fescues were 'Thor', 'MRSL TF15', 'DLFPS-321/3678', 'RS4', 'Thunderstruck' and 'Titanium LS'.

Greater statistical significance was noted, among all ET levels at Logan, UT, however no Kentucky bluegrass performed at the acceptable lawn quality level for the season average, many falling below even the minimally acceptable quality score for low maintenance (5.0). Overall, tall fescues performed better with 'Thunderstruck', 'DLFPS-321/3679', 'LTP-SYN-A3' and 'RS4' in the top turf quality statistical group under the 40% ET_o replacement (turf quality scores of 5.7, 5.5, 5.3 and 5.2 respectively). Less, but still some statistical significance was noted at the 60% ET_o regime with no statistical differences seen in tall fescue mean turf quality scores at 80% ET_o.

In the first Fort Collins, CO data, an interesting and different effect from the ET regimes was noticed. The perennial ryegrass control entry that is included in the trial was one of the lowest, or the lowest performing entry at each site, with the exception being Fort Collins. Under every ET regime, both for Kentucky bluegrass and tall fescue, the perennial ryegrass control entry was the top entry, in some cases statistically better than all entries. At the very least, the perennial ryegrass entry was statistically better than most tall fescue and bluegrass entries.

Besides the perennial ryegrass performance, 'PST-K13-141' and 'PST-K11-118' Kentucky bluegrass were consistently good at all three ET levels. For tall fescue, 'PST-5SDS' was the top

entry under 40% ET_o, while 'Catalyst', 'DLFPS-321/3678' and 'PST-R511' were also among the best performing entries under the three irrigation regimes.

The fifth reduced irrigation site, St. Paul, MN, utilized a modified ET_o schedule of 0, 25 and 75% replacement. Moderate statistical significance was noted under the three irrigation regimes, with tall fescue scoring higher overall than Kentucky bluegrass. Under the 0% and 25% regimes, no bluegrass entry finished with an acceptable lawn turf quality rating (6.0). Consistently rating near the top under all three levels include bluegrasses 'Blue Note', 'Blue Devil' and 'PST-K3-141'. Conversely, almost every tall fescue entry finished with an acceptable turf quality rating under all regimes at St. Paul. Some of the best tall fescues under each ET level include 'Nonet', 'DLFPS-321/3678' and 'PST-5SDS'.

Data from 2017 can be found here: http://www.ntep.org/reports/cs16w/cs16w_18-2.htm. As of this writing, data from 2018 will be available on the NTEP web site soon. 2019 data is being collected now and will be available in spring 2020.

SUMMARY AND CONCLUSIONS

In red are answers to the objectives and deliverables:

Objectives
The objectives of this trial are the following:

1. Determine the 100-day, summer water use of cool-season turfgrass species and cultivars. We have two years of data from six sites, and one year of data from four sites. We need three years of data to determine actual water use rates. We have however seen large differences among some entries, but not as much statistical significance as we would like to see thus far. We have adjusted our protocol slightly and it may need more tweaking. We are collecting data in 2019 and will again in 2020 for some sites.

2. Determine turfgrass recovery of grasses after 30 days and 60 days without water. Recovery has been measured but as stated in question 1 above, not as much statistical significance has been noted as we would like.

3. Determine the %ET replacement required by each entry to maintain a prescribed level of green or quality. Similar to question 1, we have only two years of data from two sites, and one year of data from four sites. We are continuing this project to obtain three years of data from all sites. One thing we can say is that all sites are not created equal, for example, the lowest (40%) and medium (60%) ET replacement did not deliver any acceptable entries at Riverside, CA, which means more breeding is needed for these grasses to be used with less water at an environment such as Riverside. At other sites, such as Las Cruces, NM, 60% ET_o did show some entries with acceptable performance, probably because some summer rains occur there. Again, we do not have enough to data to answer this question definitively.

4. Develop requirements for water use and drought tolerance/recovery to be certified as a low-water use turfgrass. See answer to questions 1 and 3…we need three years of data to make determinations.

5. Work with U.S. EPA WaterSense® or another organization to develop and apply a national water saving certification to qualified turfgrasses. We are in contact with the WaterSense office, but since EPA has been struggling with funding (Pres. Trump's first two budgets have proposed a 40% reduction in the overall EPA budget, including elimination of WaterSense), it has been impossible for WaterSense to move forward with turfgrass certification. However, we did help and support Congressional *authorization* of WaterSense, which passed last year. Authorization helps protect the WaterSense program from elimination while also allowing EPA to request separate WaterSense funding in their budget requests (they have never had a separate budget line item for Water Sense, which has restricted the program's growth).

Deliverables

1. Data will be collected on the actual amount of water needed (inches) and ET replacement levels from multiple locations need to maintain turfgrass entries at a specified quality level or prescribed level of green cover. This data will be collected for three years (2017-2019) at multiple locations across the U.S. See answers above, but we are working on this and will have a better idea when three years of data is collected from all sites.

2. The data collected will be published each year on the NTEP web site (www.ntep.org) in the same manner as other NTEP data sets. Data from year 1 (2017) is on the NTEP web site and as of this writing, data from year two is almost complete (we have over 250 pages of data tables to edit and publish for just the 2018 data from this trial). 2018 data should be on the NTEP site soon. 2019 data (being collected now) will be available in spring 2020.

3. We will work with EPA WaterSense® or another organization to develop a national certification/labeling program for low-water using turfgrasses. This program will be used to certify/label those entries that meet the requirements prescribed in advance for qualification of the label. See answer to question 5 above.

4. The certification program will be promoted and encouraged for use by water utilities, municipalities, golf courses, athletic field complexes, grounds managers and homeowners. Again, this is dependent on getting EPA Water Sense in a position to certify turfgrass (question 5 above). Also, we need to make sure our technique is scientifically sound enough to be repeatable.

5. A yearly progress report will be provided to the WTSC from NTEP. This report should be delivered to the WTSC Administration via email, no later than December 15 of each year. We did not have any data analyzed by Dec. 15, but this is the progress report (or final report) considering the latest data we have (2018). We can provide progress reports in spring 2020 and 2021 (for 2019 and 2020 data).

DR. MICHELE DACOSTA, UNIV. MASSACHUSETTS IN THE APPROACH 1 PROJECT AT AMHERST, MA, JULY 2018

FT. COLLINS, CO - 80% ET LEVEL IN FRONT, NOTE 40% ET LEVEL IN REAR

LIGHT BOX UNIT USED TO COLLECT DIGITAL IMAGES OF % GREEN COVER

THE WEST LAFAYETTE, IN SITE BEFORE DROUGHT TREATMENTS ARE INITIATED IN JUNE 2018

RIVERSIDE, CA - TOP LEFT 60% ETo, TOP RIGHT 40% ETo, BOTTOM - TRIAL OVERALL

(PICS FROM 2017, SIMILAR TO RESULTS IN 2018)

ATTACHMENT A

EXECUTIVE SUMMARY

Project Title: **National Evaluation of Cool-Season Turfgrass Water Use and Drought Resistance**

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Project Description:

With water restrictions becoming more commonplace, and with turfgrass being scrutinized for its water use, there is great need to highlight those cool-season turf cultivars that use less water and are appropriate for home lawns, athletic fields, golf courses, etc. Therefore, this project addresses that need to identify cool-season turfgrass cultivars that deliver high quality turf while using significantly less water. We propose a trial established at multiple locations nationwide that does the following: 1) measures the actual amount of water required to maintain a prescribed level of quality or green cover, and 2) documents the performance of cultivars under varying levels of reduced evapotransporation (ET) levels. We will collect three years of data on Kentucky bluegrass, perennial ryegrass, fineleaf fescue and tall fescue at 6-8 trial locations. This data will be used to develop and apply U.S. EPA WaterSense® http://www3.epa.gov/watersense/ certification (or another certification organization) label to grasses that qualify.

How Ours is Different:

This is the first national trial conducted specifically to document the amount of actual water needed to maintain a prescribed level of quality or green cover. The USGA has committed $250,000 to this project (as well as $250,000 to a warm-season grass version of this project), and has selected NTEP to develop and coordinate the trial. However, this trial is very expensive to conduct, costing between $600,000 and $750,000, considering the need to build rainout (rain eliminating) shelters, experimental areas with different irrigation zones (about $15,000 per location) and extensive data collection costs. NTEP will assess a fee per entry for testing, however, NTEP is soliciting additional funding from several sources besides Washington Turfgrass Seed Commission.

Potential Benefits or Impact on the Turfgrass Seed Industry:

This trial will provide specific information on the amount of water each cultivar needs, which is data not available at this time. This will allow us to show water utilities, municipalities and other groups that cool-season turfgrass can survive, and even thrive, with less water than previously understood. In addition, EPA WaterSense® or other certification, will justify the low water use of qualified grasses.

Deliverables:

Three years of data collected from summer 2017- 2019. Data will be published on the NTEP web site and will be used to consider grasses for certification. The Washington Turf Seed Commission will benefit from its sponsorship of this project from not only having grasses certified as low water users, but also from partnership with, and publicity from this project.

	Amount requested
Year 1 (2016)	$ 35,000
Year 2 (2017)	$ 35,000
Year 3 (2018)	$ 35,000
Requested Total	$ 105,000

ATTACHMENT A (page two)

National Evaluation of Cool-Season Turfgrass Water Use and Drought Tolerance

Background/Justification

Water use on lawns, athletic fields, parks and golf courses is being increasingly scrutinized by municipalities, water utilities, regulatory agencies and the general public. The severe drought in California has brought the issue to the forefront with the mainstream media often focusing on turf and lawn water use. Gov. Jerry Brown's executive order requiring water savings, as well as calling for the removal of 50 million sq. ft. of lawns has heightened awareness of the issue, and the subsequent need to reduce water use. As a result, several California jurisdictions are offering up to $5 per sq. ft. to remove turf (and in some cases, allowing synthetic turf as a replacement). As the western states in particular become more populated, the struggle between water utilities, commercial water users, domestic water users and agriculture for finite water resources will escalate. This trend will spread to other states and regions as well, with increasing population in many areas and a need to provide more domestic and commercial water.

Some information on turfgrass water use has been generated by universities and groups within the turfgrass industry. Currently, research has documented the relative water use among turfgrass species (see Table 1).

Table 1. Summary of Mean Summer Daily Rates of Turfgrass Evapotranspiration (ET_0).

Turfgrass species[1]					
Cool Season	Warm Season				Relative ranking
		Mean Summer ET rate[2] (mm per day)			
	Buffalograss	5.0	–	7.0	Very lov
	Bermudagrass hybrids	3.1	–	7.0	Low
	Centipedegrass	3.8	–	9.0	
	Bermudagrass	3.0	–	9.0	
	Zoysiagrass[t]	3.5	–	8.0	
Hard fescue		7.0	–	8.5	Mediun
Chewings fescue		7.0	–	8.5	
Red fescue		7.0	–	8.5	
	Bahiagrass	6.0	–	8.5	
	Seashore paspalum	6.0	–	8.5	
	St. Augustinegrass	3.3	–	6.9	
Perennial ryegrass		6.6	–	11.2	High
	Carpetgrasss	8.8	–	10.0	
	Kikuyugrass	8.5	–	10.0	
Tall fescue		3.6	–	12.6	
Creeping bentgrass		5.0	–	10.0	
Annual bluegrass			>	10.0	
Kentucky bluegrass		4.0	>	10.0	
Italian ryegrass			>	10.0	

[1] Based on the most widely used cultivars of each species.

[2] Mean rates of water use under well-watered conditions from several research studies.

ATTACHMENT A (page three)

Turfgrass Water Conservation Alliance (TWCA) members have conducted several studies that demonstrate turf water savings if appropriate cultivars are used. TWCA members, Kansas State University, the University of Arkansas, Texas A&M University and others have shown that the actual amount of water needed by drought tolerant cultivars is less than previously thought (see Attachment A). Subsequently, labeling/certification programs have been developed and endorsed by several companies (TWCA, A-List, for example).

For turfgrass to be considered low water using by regulatory agencies, water utilities, municipalities, etc. (i.e. those groups that pay to remove or restrict turf), then we need a nationally accepted certification program such as U.S. EPA WaterSense® http://www3.epa.gov/watersense/ . WaterSense® is a program that tests and certifies low water use items, such as faucets, toilets, shower heads and irrigation parts. They are now interested, and are discussing with us the certification of turfgrass, making turfgrass the first plant material they are considering certifying.

With all of this information in mind, the USGA Executive Committee agreed to provide $500,000 total to initiate a new, nationwide trial that evaluates both cool-season and warm-season turfgrass water use and drought tolerance. This amount is seed funding to start the project, with the hopes that entry fees and other grant funds can be secured to adequately and properly fund the following project objectives. Therefore, the Washington Turfgrass Seed Commission request of $105,000 is one of several requests for cooperative funding we have made, or will make of various turfgrass organizations.

Objectives

The objectives of this trial are the following:

1. Determine the 100-day, summer water use of cool-season turfgrass species and cultivars.
2. Determine turfgrass recovery of grasses after 30 days and 60 days without water.
3. Determine the %ET replacement required by each entry to maintain a prescribed level of green or quality.
4. Develop requirements for water use and drought tolerance/recovery to be certified as a low-water use turfgrass.
5. Work with U.S. EPA WaterSense® or another organization to develop and apply a national water saving certification to qualified turfgrasses.

The research outcome will identify cultivars within turfgrass species that reduce water use by 20 percent or more, as well as those that can completely recover after 30-day or 60-day period of drought.

The development of a national water savings label for commercial turfgrass cultivars will arise from this research effort. NTEP and USGA will negotiate with the U.S. EPA WaterSense®, the Alliance for Water Efficiency (AWE) or another organization to designate standards for the turfgrass water-conservation label.

Evaluation Procedures and Protocols

The trial will be established in fall 2016 at 6-8 locations nationwide (depending on funding provided – if more funding is provided, more locations can be established). One-half of those sites will be provided with a rainout shelter, and the other half will install individual zone level irrigation. Trials will be conducted to either measure actual water used (Approach 1 – see Attachment B) or performance under various reduced ET levels (Approach 2 – see Attachment B). Data will be collected for three years (2017-2019) using the protocols outlined in Attachment B. This data will be published via the NTEP web site, and will be used to determine which entries qualify for certification. Certification qualifications will be developed and applied via a committee of scientists, industry personnel and other qualified individuals.

Species Evaluated

For this first trial, we will evaluate *Kentucky bluegrass, perennial ryegrass and other cool-species (as space is available)* within the rainout shelters and zone level irrigation plots.

Deliverables

1. Data will be collected on the actual amount of water needed (inches) and ET replacement levels from multiple locations need to maintain turfgrass entries at a specified quality level or prescribed level of green cover. This data will be collected for three years (2017-2019) at multiple locations across the U.S.

2. The data collected will be published each year on the NTEP web site (www.ntep.org) in the same manner as other NTEP data sets.

3. We will work with EPA WaterSense® or another organization to develop a national certification/labeling program for low-water using turfgrasses. This program will be used to certify/label those entries that meet the requirements prescribed in advance for qualification of the label.

4. The certification program will be promoted and encouraged for use by water utilities, municipalities, golf courses, athletic field complexes, grounds managers and homeowners.

Benefits to Washington Turfgrass Seed Growers

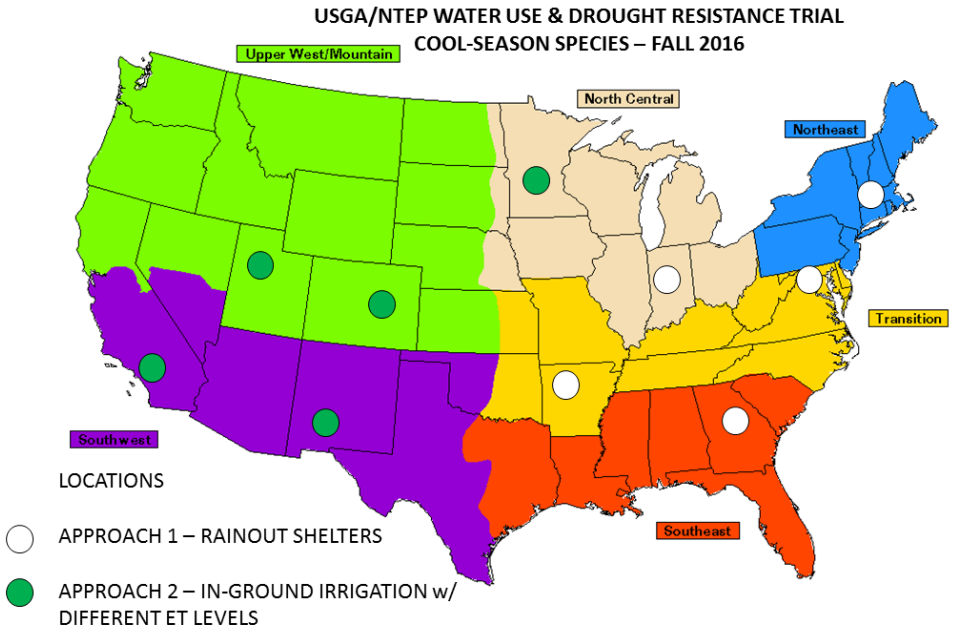
The support of this project from the Washington Turfgrass Seed Commission will help seed growers in the following ways: 1) it will increase the use of drought tolerant cool-season grasses, especially in those regions where drought conditions are a concern, 2) low-water use certified (EPA WaterSense® or other) turfgrasses will allow turf to be used again in places where turf and lawns are being restricted, 3) it will show the general public that the turfgrass industry is responding to drought conditions by reducing water use on turfgrass, and 4) it will bring positive publicity to the Washington Turfgrass Seed Commission as their sponsorship of this project is promoted in the media, alongside NTEP, USGA and other sponsors that we are able to attract.

About the PI's

Mr. Kevin Morris is the first, and longest tenured employee of the National Turfgrass Evaluation (NTEP), being named Executive Director in 1998. NTEP is the world's leading turfgrass evaluation program. Starting in 1980, NTEP has led the way by developing evaluation techniques and delivering high quality research results on cool-season and warm-season turf species. NTEP pioneered the delivery of unbiased research results on its web site (www.ntep.org), which is freely available. Currently, NTEP is evaluating over 600 grasses, encompassing fifteen species, utilizing testing facilities in 36 U.S. states and two Canadian provinces. .

Dr. Michael P. Kenna has been the Director of USGA Green Section Research since February, 1990. He oversees the USGA's turfgrass and environmental research activities, including soliciting and evaluating research proposals, grant making, and development of cooperative funding with government and commercial sources. Dr. Kenna travels extensively to visit turfgrass and environmental research sites, speak at conferences about the USGA's research programs, and serves on advisory boards and research foundations. He has worked closely with the US Department of Agriculture on water and energy conservation research that relates to golf courses. Dr. Kenna has served as editor on several books concerning turfgrass biotechnology, environmental issues, and water conservation and reuse.

ATTACHMENT B



USGA/NTEP Water Use & Drought Resistance Trial
Cool-season grass locations

Approach 1
(restrict water
For 100 days)

Amherst, Massachusetts
College Park, Maryland
Griffin, Georgia
W. Lafayette, Indiana
Fayetteville, Arkansas

Approach 2
(reduced
ET_o levels)

St. Paul, Minnesota
Las Cruces, New Mexico
Riverside, California
Logan, Utah
Ft. Collins, Colorado

ATTACHMENT C

2016 National Cool-Season Water Use/Drought Resistance Test

Entries and Sponsors

Entry No.	Name	Species	Sponsor
1	BAR PP 110358	Kentucky Bluegrass	Barenbrug USA
2	Barrari	Kentucky bluegrass	Barenbrug USA
3	Everest	Kentucky bluegrass	Jacklin Seed by Simplot®
4	Blue Note	Kentucky bluegrass	Mountain View Seeds
5	Babe	Kentucky bluegrass	Seeds, Inc.
6	NAI-13-132	Kentucky bluegrass	Columbia River Seed
7	NAI-13-14	Kentucky bluegrass	Columbia River Seed
8	Blue Devil	Kentucky bluegrass	Columbia River Seed
9	Dauntless	Kentucky bluegrass	Columbia River Seed
10	PST-K13-137	Kentucky bluegrass	Pure-Seed Testing, Inc.
11	PST-K13-143	Kentucky bluegrass	Pure-Seed Testing, Inc.
12	PST-K15-169	Kentucky bluegrass	Pure-Seed Testing, Inc.
13	PST-K11-118	Kentucky bluegrass	Pure-Seed Testing, Inc.
14	PST-K13-141	Kentucky bluegrass	Pure-Seed Testing, Inc.
15	Midnight	Kentucky bluegrass	Standard entry
16	SR 4650	perennial ryegrass	Standard entry
17	BarRobusto	tall fescue	Barenbrug USA
18	BAR FA 121095	tall fescue	Barenbrug USA
19	DLFPS 321/3677	tall fescue	DLF Pickseed USA
20	DLFPS 321/3679	tall fescue	DLF Pickseed USA
21	DLFPS 321/3678	tall fescue	DLF Pickseed USA
22	Nonet	tall fescue	Jacklin Seed by Simplot®
23	GO-AOMK	tall fescue	Grassland Oregon
24	Supersonic	tall fescue	Mountain View Seeds
25	Titanium 2LS	tall fescue	Mountain View Seeds
26	Thor	tall fescue	Columbia Seeds
27	Thunderstruck	tall fescue	Columbia Seeds
28	RS4	tall fescue	Landmark Turf & Native Seed
29	Kingdom	tall fescue	Site One Landscape Supply
30	MRSL TF15	tall fescue	Site One Turf & Landscape Supply
31	Catalyst	tall fescue	Standard entry
32	Stetson II	tall fescue	Site One Landscape Supply
33	PST-5SDS	tall fescue	Pure-Seed Testing, Inc.
34	PST-R511	tall fescue	Pure-Seed Testing, Inc.
35	LTP-SYN-A3	tall fescue	Lebanon Seaboard Corp.

ATTACHMENT D

July 25, 2016 version

Trial details:

1. Cool-season grass trials (two species) will be established in 10 locations for each species in fall 2016.

2. Data will be collected for three growing seasons: 2017, 2018 and 2019

3. Two approaches will be used:

   Approach 1 – individual plot watering and
   Approach 2 – zone level irrigation (see pages two and three for a description of each approach).

4. An equal number of rainout shelters and zone level irrigation plots will be built (see attached map and locations list). The rainout shelters will be utilized where summer rainfall is possible (and needs to be restricted).

5. Since plot space will be limited, the first priority for entries will include only Kentucky bluegrass and tall fescue. If space is not filled with those two species, some perennial ryegrass entries can be included in the trial.

6. Trial locations will be managed using a mowing height of 2 – 2.5" and fertilization of 0.25 – 0.33 lbs. of N/1000 sq. ft./growing month.

7. Digital image technology will be used to measure percent green cover on plots. Training will be provided to cooperators so that images are collected properly.

8. NTEP will hire additional staff to monitor the performance of trials, data and image collection, and to perform site visits.

9. Since the plot areas will be costly to build and the trial will require considerable labor to manage, each species trial will be limited to 30 total paid entries (plus 3 standards), 3 reps of each for a total of 100 plots at each test site.

10. USGA and NTEP will pursue certification/qualification and/or branding of drought tolerant or low-water using cultivars. Therefore, we anticipate that at the end of the trial period, the system will be in place to apply this certification (or brand) to those entries that qualify (qualification requirements will be in place before entry submission).

Rainout shelters similar to this will be built and installed at five locations (see map)

ATTACHMENT D (page two)

Here are more details on the two proposed water use/drought approaches. These approaches are based on similar protocols reported by Kansas State University, University of Arkansas and others (see selected references below):

1) **<u>Approach 1- Individual Plot Level Irrigation:</u>**. The amount of plant material per entry would need to be sufficient to establish to a final area of approximately 32.28 sq. ft per entry per site. (*10.76 sq. ft./plot x 3 reps*)
    a. Year 1- Plots are fully established under full irrigation levels (plot size is *1 meter x 1 meter or 10.76 sq. ft.)*
    b. Years 2, 3, 4, etc.- Following uniform irrigation of all plots to initiate the study, full scale, automated irrigation is terminated, and individual plots are thereafter monitored on a regular basis (*could be daily, bi-weekly, or weekly to correspond to particular watering frequencies allotted by the region or budget provided the cooperator*) during the morning hours of the dry-down 'season'.
    c. When quality attributes (*wilt/firing/% green cover, etc.*) of a specific plot or plots are noted to have fallen below a defined threshold (*i.e. 50% green cover or another prescribed level*), it is hand-irrigated with an amount of water necessary to recharge the root zone to field capacity (between ½" to 1"). Irrigation events are recorded on a per plot basis, so that total irrigation applied over the season can be calculated on a plot basis and statistics applied.
    d. A dry-down 'season' would last around 100 days, then plots would be fully irrigated to assess recovery. Turf quality ratings will be collected as well during dry down and recovery.
    e. A rain-out shelter will be employed for this approach. Data produced through the work would document 1) 'water quantity required (inches) per entry' for each location, 2) turfgrass quality before and during dry-down, during and after recovery, and a 3) ranking of the entries used.

    Selected References:

Lewis, J.D. et al. 2012. Wilt-Based Irrigation in Kentucky Bluegrass: Effects on Visual Quality and Irrigation Amounts Among Cultivars. Crop Sci. 52:1881–1890. doi: 10.2135/cropsci2012.01.0033

Richardson, M. D. el al. 2009. Drought Tolerance of Kentucky Bluegrass and Hybrid Bluegrass Cultivars. Online. Applied Turfgrass Science. doi:10.1094/ATS-2009-0112-01-RS.

Richardson, M.D. et al. 2012. Irrigation Requirements of Tall Fescue and Kentucky Bluegrass Cultivars Selected Under Acute Drought Stress. Online. Applied Turfgrass Science doi:10.1094/ATS-2012-0514-01-RS.

Steinke, K. et al. 2010. Drought Response and Recovery Characteristics of St. Augustinegrass Cultivars. Crop Sci. 50:2076-2083. doi:10.2135/cropsci2009.10.0635. Published online 16 June 2010.

USGA Turfgrass and Environmental Research Online. Vol. 11, No. 6, June 1, 2012, p. 1-12. http://www.lib.msu.edu/cgi-bin/flink.pl/?recno=205406

Plots would be individually watered after they reach the desired drought stress threshold.

ATTACHMENT D (page three)

Approach 2- Zone Level Irrigation: Larger study area size (~3 to 4 times more area and plant material) would be needed for accommodating multiple studies or 'zones' of irrigation. The amount of plant material per entry would need to be sufficient to establish to a final area of approximately (3 ET levels x 3-6 entry reps/ET level x 10.76 sq. ft) ~200 sq. ft. per location *(depends on location irrigation design and availability)*. This trial would not be conducted under rainout shelter due to size constraints.

a. Year 1- Similar to Approach 1, a full set of replicated entries would be established, but within each of 3 target irrigation ET levels (zones). Plots (*1 m x 1 m or similar size*) will be fully established under full irrigation levels.
b. Years 2-4- Irrigation treatments imposed. ET levels will correspond to 3 levels of historical reference evapotranspiration (ET_o) for the location, the maximum of which should be near full water requirement (~0.75 x ET_o for cool-season) and lowest of which should be ~1/4 of this maximum level. Alternatively, if ET_o data are unavailable, one could arbitrarily apply defined amounts (i.e. ¾" per week, ½" per week, and ¼" per week to the respective zones.
    i. Cool-season: 0.75 x ET_o, 0.5 x ET_o, 0.25 x ET_o applied 2x weekly
c. Frequency of irrigation to plots would also be a constant 1 or 2 day per week irrigation schedule *(a single frequency should be decided on for all locations)*.
d. Irrigation scheduling to account for rainfall
    i. Approach 1- Let system run regardless of rainfall, do not adjust irrigation
    ii. Approach 2- Do not adjust schedule for any events <0.25". Account for 50% effective rainfall for all other events in adjusting irrigation applied for each zone. (For instance, if a 1" rainfall is received; all plots are turned off for one event. If ½" is received, only the low irrigation level may be turned off, but others receive appropriate % adjustments to account for ¼" effective rainfall.
    iii. Ultimately the key will be accurate accounting of total water received within each zone on a weekly basis.
e. Quality attributes (*wilt/firing/% green cover, etc.*) of all plots within each irrigation level will be noted regularly during the study, just prior to an irrigation day during the morning hours.
f. At the conclusion of the study, irrigation + rainfall for each zone would be totaled by week (~10-14 weeks in duration). Quality (>6) or other parameter (>75% green cover) of interest in determining acceptability would also be noted on a per plot basis for each week. Finally, the particular amount of water needed to sustain acceptable quality each week would be determined on a plot by plot basis and totaled for the study. This amount might fluctuate by week or month. For example, bluegrass may maintain acceptable quality with only 0.5 x ET_o in June, but in July or August, may require 0.75 to maintain acceptability. This method will account for weekly or monthly changes in minimal irrigation levels required.
g. This approach is best suited for areas of the US that likely see visible drought stress arise in summer months where irrigation is not applied, i.e. (New Mexico, California, Colorado, etc.).
h. Repeating the studies over three years will allow for upper and lower end seasonal requirements to be determined for each location.
i. Data produced through the work would also document 1) 'water quantity required (inches)' per entry for each location, 2) turfgrass quality ratings at regular intervals, and a 3) ranking of the entries used.