Drought Tolerance of Consumer Turfgrass Seed Mixtures and Blends

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Introduction

Turfgrass and water usage:

- Lawns are the single largest irrigated area in the United States, accounting for over 40 million irrigated acres.[1]
- In the Twin Cities Metro Area (St. Paul and Minneapolis) area, approximately 20% of all treated drinking water is used on lawns and landscapes.
- Increased use of water for irrigation has become a concern in the Twin Cities especially during seasonal drought when demand for fresh water is highest.

Why are homeowners watering their lawn during seasonal drought?

- Homeowners fear their grass will die.
- Homeowners want their lawn to stay green.

→Homeowners could improve water conservation by choosing the right type of turfgrass species to meet their expectations.

Cool season perennial grasses drought tolerance:

- Species known to be intolerant to drought: perennial ryegrass (PR), annual ryegrass (AR), Kentucky bluegrass (KBG), rough bluegrass (RBG).[2]
- Species known to be tolerant to drought: tall fescue (TF) and fine fescue species (FF).[2]
- Most research studying drought tolerance was performed on single species.[3]

However:

- Few studies exist on drought tolerance in species mixtures.
- Effect of mowing height on drought tolerance in mixtures was never examined.

Research Objectives

1. Evaluate the drought tolerance characteristics of consumer-available turfgrass seed mixtures and blends.

2. Evaluate the effect of mowing height on drought tolerance and recovery from drought.

Materials and Methods

Establishment:

- 29 different consumer-available mixtures and blends were established under a fully-automated rainout shelter (Table 1).
- Seeding rate: 9.85 g m^{-2} (2 lb. of product 1000 $ft.^{-2}$) to 98.5 g m^{-2} (20 lb. of product 1000 $ft.^{-2}$) were sown in September (2016 and 2017) in 0.8 m^2 plots and covered with a wood fiber blanket.
- Plots were fertilized at establishment and in spring for a total of 147 kg of N h^{-1}.
- Roundup Max (4.8 L h^{-1}) was applied prior to establishment.

Mowing treatments: 5.08 cm (2”) and 8.89 cm (3.5”), mowed 2x per week.

Drought Stress treatment:

- **2017 experiment:** 60-day drought; June 1st - July 30th.
- **2018 experiment:** 50-day drought; June 4th - July 25th.

Recovery period:

- Drought periods were followed by a recovery period of 28 days.
- Plots received 2.54 cm (1”) of water twice per week.

Data collected: Digital images were taken weekly and analyzed for percent green cover using ImageJ [4] and color threshold settings previously described by Soldat et al. (2012).[5]

- Following parameters calculated:
  1. **Green stability (GS):** Refers to the number of days where the percentage of green cover was not statistically different from the first time point (7 days).
  2. **The overall turf coverage (GDS):** Refers to the percentage of green cover after 60-50 days of drought.
  3. **The increase in turf coverage:** Refers to the increase of percentage of green cover between the first time point of the recovery period (7 days) and the last time point of the drought period.

Statistical analysis:

- **Green stability:** Comparisons between time points were performed for each mix and blend using a one-way analysis. Means were compared using Student’s t-test.
- **Overall turf coverage (GDS) and increase of turf coverage:** Comparisons between mixes and blends and the interaction with the mowing practice were analyzed using a linear model with a Standard Least Square personality. Means were compared by using ANOVA (F ratio) and pairwise Student’s t-test.
- Statistics were performed using JMP® PRO 13.
- **Principal component regression analysis** were performed as previously described in Petrella et al. (2018). [6]

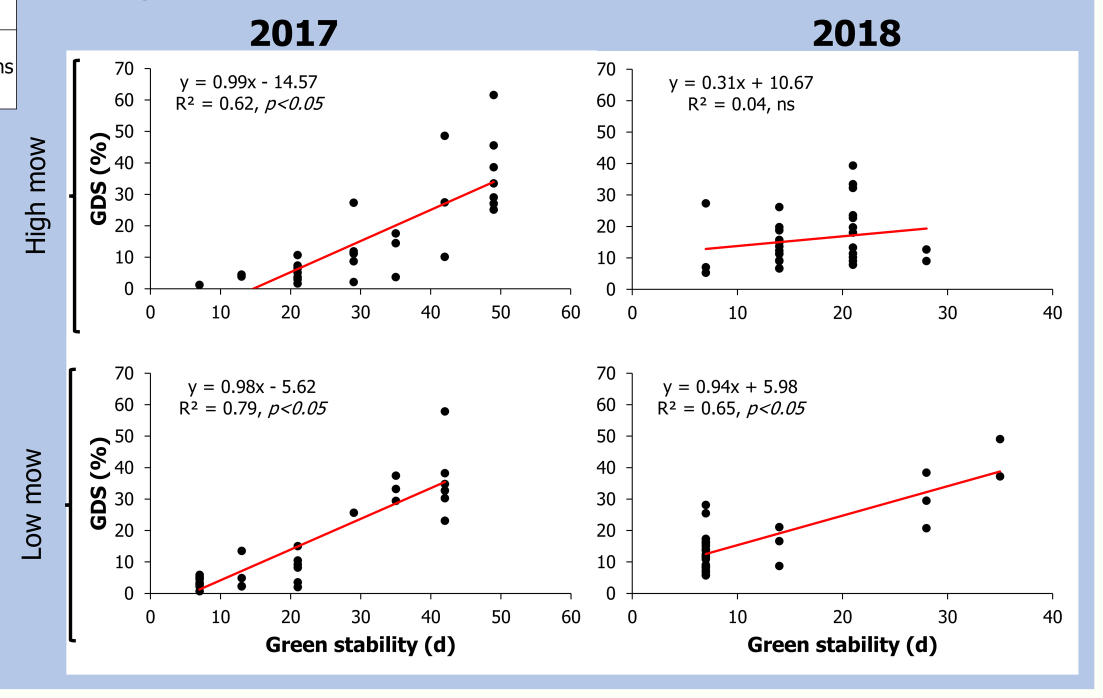
		species composition (%)							2017		2018	
Packaging Name	**Manufacturer**	**PR**	**AR**	**KBG**	**RBG**	**TF**	**FF**	**AKG**	GS-HM	GS-LM	GS-HM	GS-LM
Green Turf Sun Shade Lawn	Barenbrug USA	32	11	21	0	0	**37**	0	21	13	14	7
Heat-Tolerant Blue Mix (3-1-0)	The Scotts Company	0	0	8	0	**92**	0	0	49	35	21	35
Full Sun Grass Seed	Bonide Products	**55**	0	25	0	0	20	0	21	13	14	7
Bachman's Boulevard Mix	JRK Seed	0	0	10	0	0	**90**	0	42	29	7	14
Bachman's Sunny Mix	JRK Seed	30	10	25	0	0	**35**	0	14	7	14	7
Bachman's Shady Mix	JRK Seed	10	0	15	0	0	**75**	0	29	21	14	7
Quick & Thick Lawn Seed	X-Seed	**56**	0	15	0	0	29	0	21	7	21	7
Beisswenger's Elite Overseeding	Twin City Seed Co.	30	0	**70**	0	0	0	0	29	7	14	7
Beisswenger's Shady Mix	Twin City Seed Co.	10	0	20	10	0	**60**	0	21	7	14	7
Schultz Sun & Shade Mix Grass	Barenbrug USA	**36**	16	20	0	0	29	0	21	21	28	7
Schultz High Traffic Lawn Grass	Barenbrug USA	**70**	20	10	0	0	0	0	29	7	21	7
Nature's Finest Thick 'n Hardy	Performance Seed	**49**	10	20	0	0	20	0	14	7	28	7
Turf Champ Sunny Grass Seed	Performance Seed	**41**	**41**	18	0	0	0	0	21	13	7	7
grassology Grass Seed Mixture	Telebrands	16	0	10	0	20	**53**	0	35	13	14	7
Superior Blue Blend Mixture	Mountain View Seeds	0	0	**100**	0	0	0	0	42	35	14	14
Drought Defy Premium Grass	Mountain View Seeds	5	0	10	0	**85**	0	0	49	42	21	7
Superior Northern Lawn Mixture	Mountain View Seeds	**70**	0	18	0	0	12	0	35	21	14	7
Tuff Turf Mix	Ramy Turf Products	0	0	9	0	91	0	0	49	42	21	28
Cut Less II Low Growing Mix	Ramy Turf Products	0	0	0	0	0	**100**	0	49	35	21	7
Vigoro Tall Fescue Grass Seed	Barenbrug USA	0	0	0	0	**100**	0	0	42	42	21	28
Vigoro Curbside Mix & Perfect	Barenbrug USA	**40**	20	0	10	0	0	30	7	7	7	7
Premium Sun & Shade Mixture	Lesco	32	0	32	0	0	**36**	0	35	21	21	14
Heartland Sun & Shade Mixture	Pennington Seed	**62**	30	9	0	0	0	0	21	7	14	7
Smart Seed Fescue/Bluegrass	Pennington Seed	0	0	10	0	**90**	0	0	49	42	21	28
Smart Seed Sun & Shade Mix	Pennington Seed	0	0	10	0	**76**	14	0	49	42	21	35
Smart Seed Midwest Mix	Pennington Seed	**67**	0	16	0	0	16	0	29	7	21	7
Midwest Mix (3-1-0)	The Scotts Company	30	0	42	0	0	28	0	29	21	14	7
Sun & Shade Mix (3-1-0)	The Scotts Company	**41**	0	19	0	0	40	0	29	7	14	7
Kentucky Bluegrass Mix (3-1-0)	The Scotts Company	0	0	**100**	0	0	0	0	49	42	21	7
	Average	27	5	23	1	19	24	1	32	21	17	12

Table 1: Packaging name, manufacturer, and species composition of each consumer-available mixtures and blends. Bold number indicates the species that possess the highest percentage of weight. GS-HM and GS-LM represents the Green Stability (GS) at high mow (HM) and low mow (LM) for 2017 and 2018.

2017		2018	
HM	LM	HM	LM
17.23	15.05ns	15.94	16.91ns

Table 2: Average overall turf coverage (percentage of leaf coverage) at the end of the drought period at high mow (HM) and low mow (LM) for 2017 and 2018. ns indicates that the turf coverage was non statically different between the mowing practices.

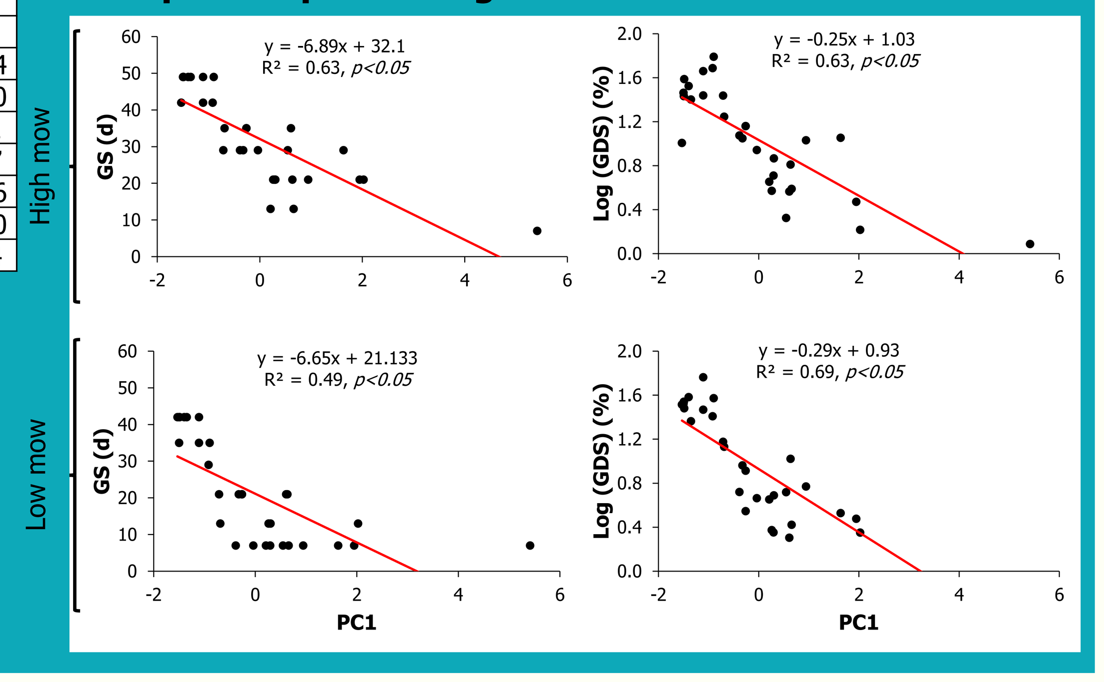
Linear regression analysis between the green stability and the overall turf coverage (GDS) at the end of the drought stress period



Eigenvectors				
	PC1	PC2	PC3	PC4
PR	0.45	-0.43	-0.17	-0.24
AR	0.48	-0.12	-0.32	-0.20
KBG	-0.14	-0.35	-0.05	0.81
RBG	0.41	0.44	0.31	0.27
TF	-0.36	0.54	-0.40	-0.16
FF	-0.10	-0.09	0.78	-0.30
AKG	0.49	0.42	0.07	0.24

Table 3: PCA results obtained with the species composition from the 29 available consumer mixes and blends.

Principal component regressions with 2017 data

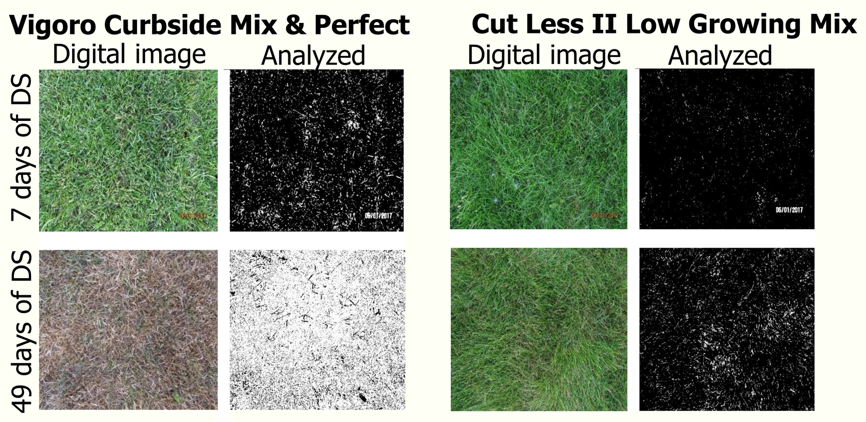


2017		2018	
HM	LM	HM	LM
23.72	30.77*	10.92	15.07*

Table 4: Increase of turf coverage between the last time point of the drought period and the first time point of the recovery period at high mow (HM) and low mow (LM) for 2017 and 2018. * indicates statistical difference between the mowing heights.

Rain-out shelter

Example of plots analyzed for their turf coverage using ImageJ



Longer green stability during acute drought stress is related to higher mowing practice

- Green stability was reduced in 2018 for both mowing heights (Table 1).
- Green stability was longer for the high mow treated consumer mixtures or blends compared to lower mowed plots (in 2017 and 2018).

→ **Higher mowing height led to longer green stability.**

- TF and FF species presence in consumer mixes or blends showed longer stability when compared to consumer mixes made of PR, AR and RBG in both mowing heights.

→ **Presence of AR, AR and RBG seemed to decrease the green stability of the mix (for all mowing heights) during the drought stress experiment.**

- Two blends of KBG, “Kentucky Bluegrass Mix (3-1-0) ” and “Superior Blue Blend Mixture” presented longer green stability, comparable to TF and FF species containing mixtures, in both mowing heights. The cultivars used by the manufacturers seemed to be stable during long period of drought.

- “Vigoro Curbside Mix and Perfect” presented the lowest green stability in both mowing heights.
- AKG was very sensitive to drought, and plots started to decline 7 days after the drought was started.

Overall turf coverage after acute drought stress is associated with green stability

2017-2018: Overall turf coverage of all consumer mixes and blends were affected by the long period of drought for both mowing heights. At the end of the acute drought stress period, the averages of the overall turf coverage were not significant between the two mowing heights (Table 2).

2017: Strong and significant correlations between the green stability and turf coverage at the end of the drought stress period for both mowing heights.

2018 High Mow: No significant correlation (positive trend) was observed between the green stability and overall turf coverage.

2018 Low Mow: Strong positive correlation between green stability and overall turf coverage.
→ **Plots with longer green stability tended to have higher turf coverage at the end of acute drought stress.**

Non-drought tolerant species alter the drought response of the consumer mixes and blends

Principal component regression analysis was used to determine if green stability and overall turf coverage could be correlated with the turfgrass species composition present in the mixture.

PCA analysis showed four significant principle components:

- **PC1** contained species that are known to be sensitive-to-drought species: PR, AR, RBG and AKG.
- **PC2** contained TF.
- **PC3** contained the FF species pooled together (hard fescue, sheep fescue, creeping red fescue and Chewings fescue).

2017 Principal component regression (data not shown for 2018)

- Strong and significant correlations obtained using PC1.
- Negative correlations observed between the green stability (GS) and PC1 for both mowing heights.
- Negative correlations observed between the overall turf coverage (GDS) and PC1 for both mowing heights.

→ **Increasing presence PR, AR, RBG and AKG negatively affected green stability and overall turf coverage.**

No strong or significant correlations observed when green stability and overall turf coverage were regressed against PC2 (Tall fescue) and PC3 (pooled fine fescue species).
→ **The negative influence of PR, AR, RBG and AKG had a stronger effect on the green stability and overall turf coverage than the presence of the TF and FF species.**

Lower mowing height improves turf recovery after acute drought stress

2017 and 2018: The increase in turf coverage between the last time point of the drought period and the first time point of the recovery period demonstrated that:

1. Mixes and blends recovered from acute drought stress under both mowing heights.
2. However the low mowing height treatment recovered stronger than the high mowing height for both years.

→ **Lower mowing height promotes turfgrass recovery after acute drought period.**

Conclusions

- Higher mowing height favors green stability and leads to higher turf coverage at the end of acute drought stress period.
- Turfgrass mixtures and blends survive acute drought stress and the recovery happens within 7 days of irrigation.
- Lower mowing height during the recovery period promotes better increase of turf coverage.
- Presence of PR, AR, RBG and AKG will negatively influence the tolerance of a mix toward long period of drought. Homeowners in Minnesota and similar climates should choose mixtures containing highest presence of tall fescue and fine fescue species.

References:

1. Milesi et al. (2005). Mapping and Modeling the Biogeochemical Cycling of Turf Grasses in the United States. *Environmental Management*. 36
2. Kopp, Kelly L. and Yiwei Jiang. (2013). Turfgrass water use and physiology. In Turfgrass: Biology, Use, and Management. Agronomy Monograph No. 56. American Society of Agronomy, Soil Science Society of America, Crop Science Society of America. Madison, WI
3. Wang et al. (2017). Differential Physiological Responses and Genetic Variations in Fine Fescue Species for Heat and Drought Stress. J. AMER. SOC. HORT. SCI. 142(5):367–375.
4. Schneider et al. NIH Image to ImageJ: 25 years of image analysis. Nat Methods. 2012 Jul;9(7):671-5.
5. Soldat et al. Quantifying turfgrass cover with digital image analysis using ImageJ. Agronomy Abstracts, American Society of Agronomy, Madison, WI. (2012).
6. DP Petrella et al. (2017). Effects of Blue Light and Phenotype on Anthocyanin Accumulation in Accessions and Cultivars of Rough Bluegrass. *Crop Science*. 54

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