Introduction

Turfgrass and water usage:
Lawns are the single largest irrigated area in the United States, accounting for over 40 million 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 mixes.
• Effect of mowing height on drought tolerance in mixes was never examined.

Research Objectives
1. Evaluate the drought tolerance characteristics of consumer-available turfgrass seed mixes and blends.
2. Evaluate the effect of mowing height on drought tolerance and recovery from drought.

Materials and Methods

Establishment:
• 29 different consumer-available mixes 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 m² plots and covered with a wood fiber blanket.
• Plots were fertilized at establishment and in spring for a total of a 147 kg N ha⁻¹.
• Roundup Max (4.8 l. ha⁻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 ImageJ4 and color threshold settings previously described by Soldat et al. (2012).5
A fixed panic area was 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 cover (GDS): Refers to the percentage of green cover after 60-50 days of drought.
• 3. The increase in turf cover: 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 cover (GDS) and increase of turf cover:
Comparisons between mixes and blends and the interaction with the mowing practice were analyzed using 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

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 mixes 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.
• "Vigoros Curbside Mix and Perfect" presented the lowest green stability in both mowing heights.

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 cover 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 cover.
• 2018 Low Mow: Strong positive correlation between green stability and overall turf cover.
• Plots with longer green stability tended to have higher turf cover 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 cover could be correlated with the percentage of species mixing 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 AKB.
• 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.
• Increasing presence PR, AR, RBG and AKB negatively affected green stability and overall turf cover.

Lower mowing height improves turf recovery after acute drought stress
2017 and 2018: The increase in turf cover 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 cover at the end of acute drought stress period.
Turfgrass mixes 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 AKB 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.