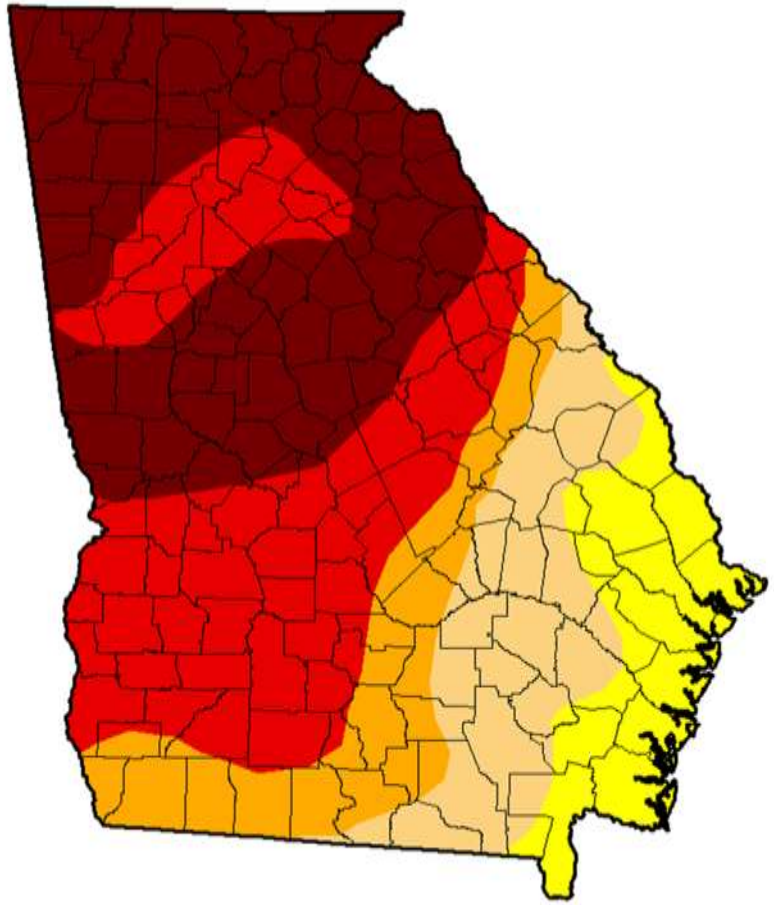
Mechanisms of Drought Tolerance in Warm-Season Grasses

David Jespersen,
Monique Leclerc, Paul Raymer
University of Georgia

Background

Drought stress

- Highly Damaging Abiotic stress
  - Reduced Growth
  - Wilt
  - Leaf Firing
  - Plant Death
- Water is a resource of great concern, and there is increased desire for sustainability in turf areas
- Need for understanding drought tolerance mechanisms and development of improved cultivars

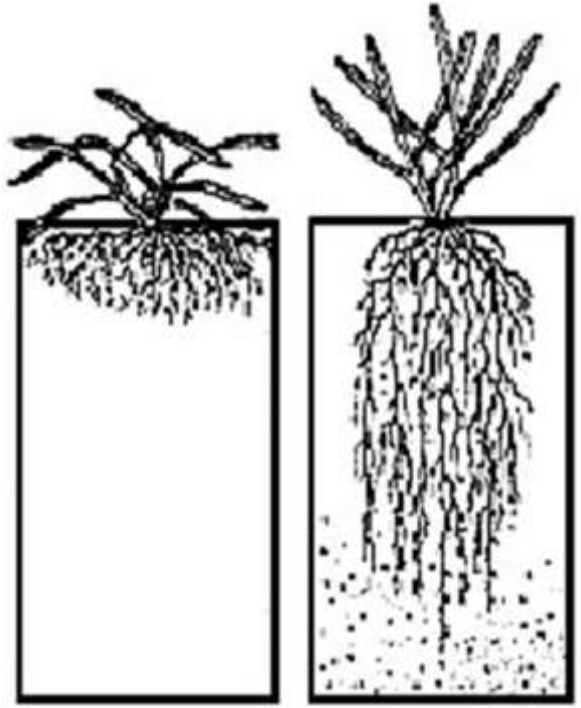


Damages Caused by Water Stress

- Reduced photosynthesis and increased respiration,
- Production of reactive oxygen species
- Damage to cell membranes
- Protein denaturation due to dehydration, and ROS damage

Mechanisms of Drought Tolerance

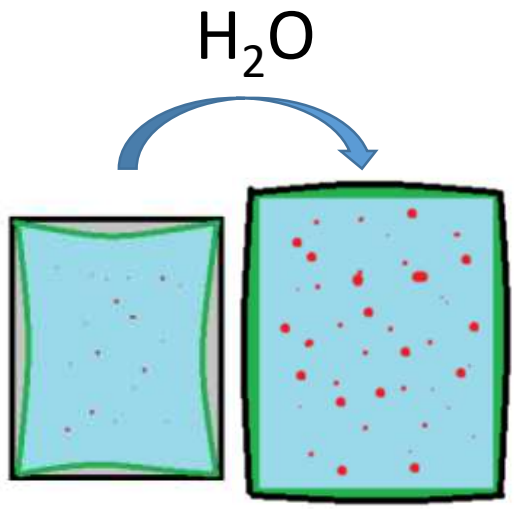
- Drought Avoidance
- Increased Rooting
- Limit Transpirational Water Loss



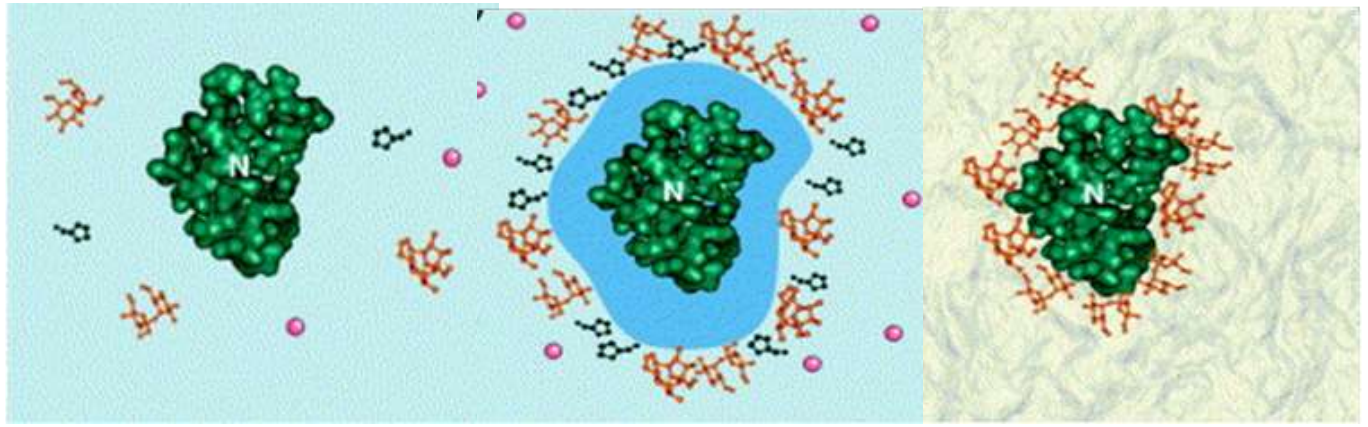
- Drought Tolerance
- Accumulation of compatible solutes
- Antioxidant metabolism
- Protective proteins

Mechanisms of Drought Tolerance

- Drought Avoidance
- Increased Rooting
- Limit Transpirational Water Loss



- Drought Tolerance
- Accumulation of compatible solutes
- Antioxidant metabolism
- Protective proteins



Study Objectives

Objectives

- Screen a collection of warm-season grasses for drought performance
- Measure physiological parameters associated with drought in bermudagrass and seashore paspalum cultivars
- Understand potential mechanisms responsible for differences in drought tolerance

Materials & Methods

Plant Materials

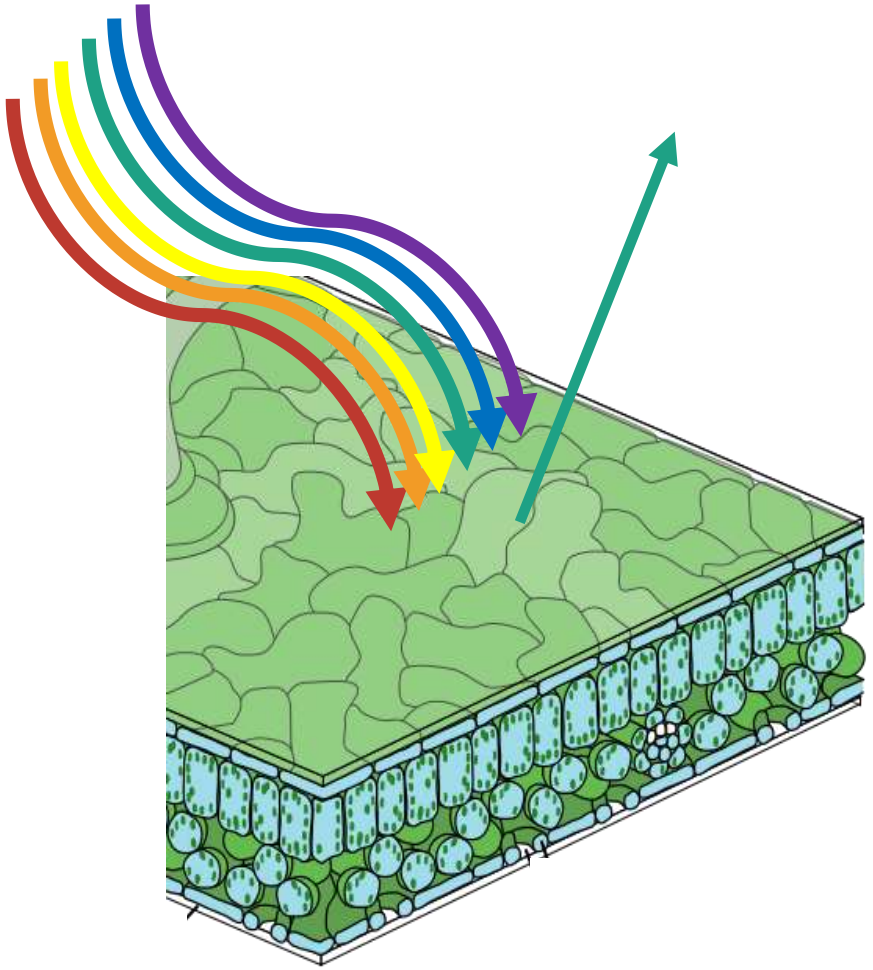
- 4 Warm-season species
- Zoysiagrass - 13 lines
- Seashore Paspalum - 9 Lines
- Bermudagrass -13 lines
- St. Augistinegrass -13 lines
- Mostly breeding materials of SCRI programs
- Each species had 3 commercial cultivars
- Focus on 6 cultivars in depth
- 4 replicates, RCBD, 3’ x 5’ plots

Drought Stress Conditions

- Plots maintained well-water till beginning of dry down period
- During dry down
  - All irrigation withheld
  - Automatic Rainout shelter to exclude rainfall
- After a period of time, plots rewatered and allowed to recover until next dry down
- Fall 2015, Spring 2016, Fall 2016, Spring 2017

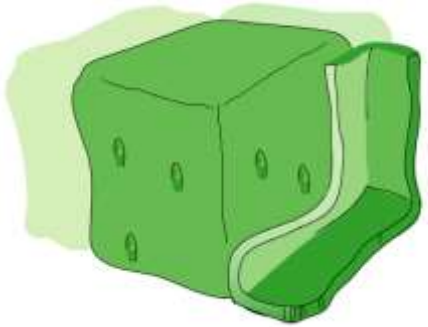
Measurements

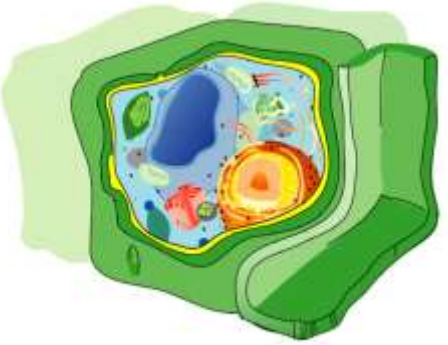
- Visual Quality Ratings
- Digital image analysis
  - % Green Cover
- NDVI
  - Green Seeker
- Membrane Stability
- Leaf Hydration Status
- Canopy Temperature
- Osmotic Adjustment
- Respiration Rate

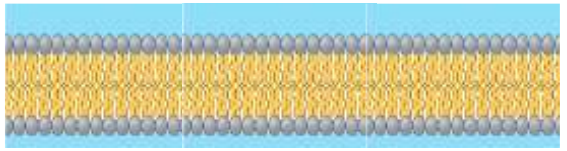


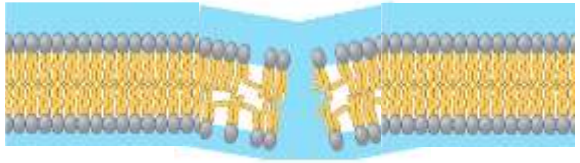
Measurements

- Visual Quality Ratings
- Digital image analysis
- NDVI
- Membrane Stability
  - Electrolyte Leakage
- Leaf Hydration Status
  - Relative Water Content
- Canopy Temperature
  - Infrared Thermometer
- Osmotic Adjustment
  - Vapor pressure osmometer
- Respiration Rate



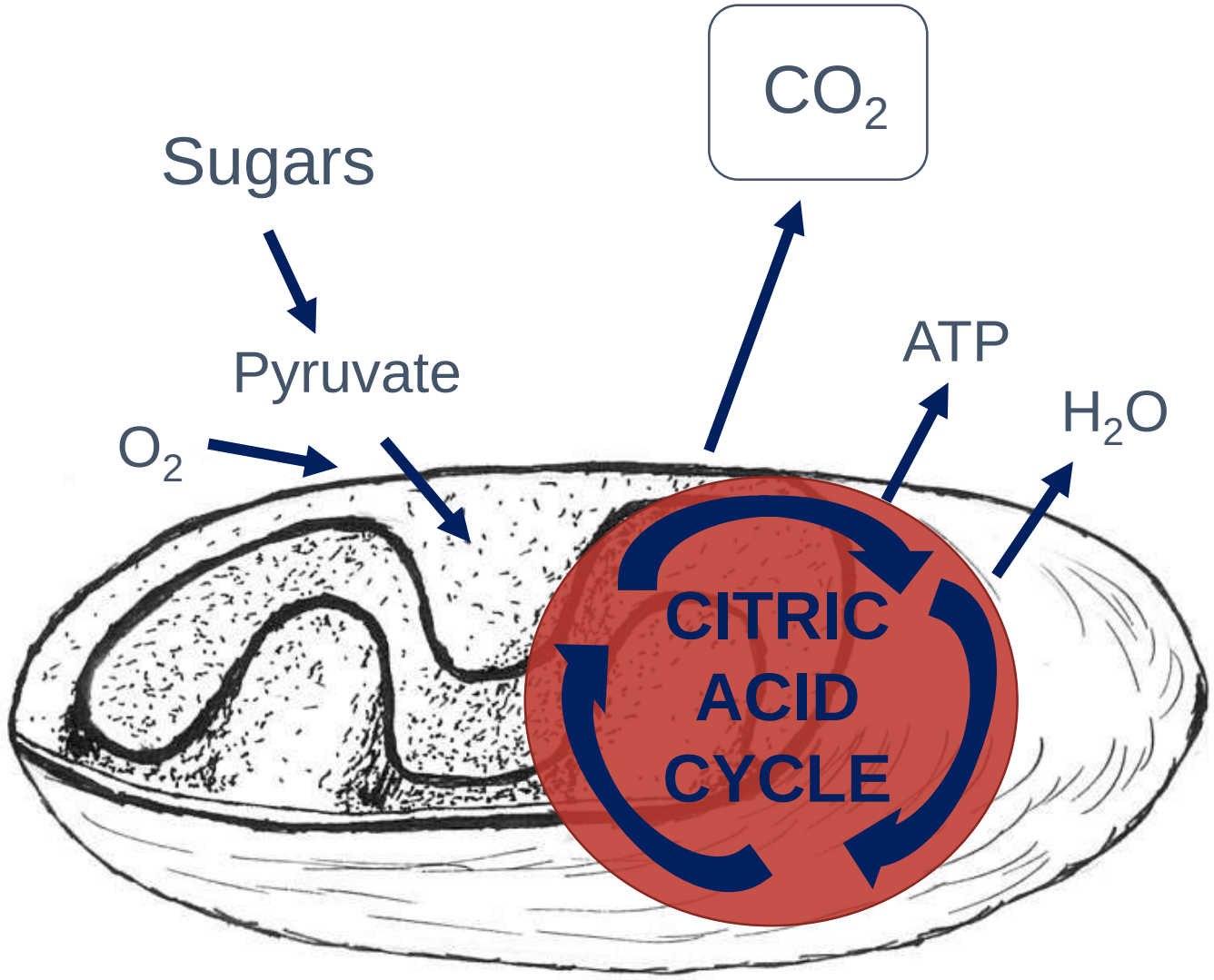






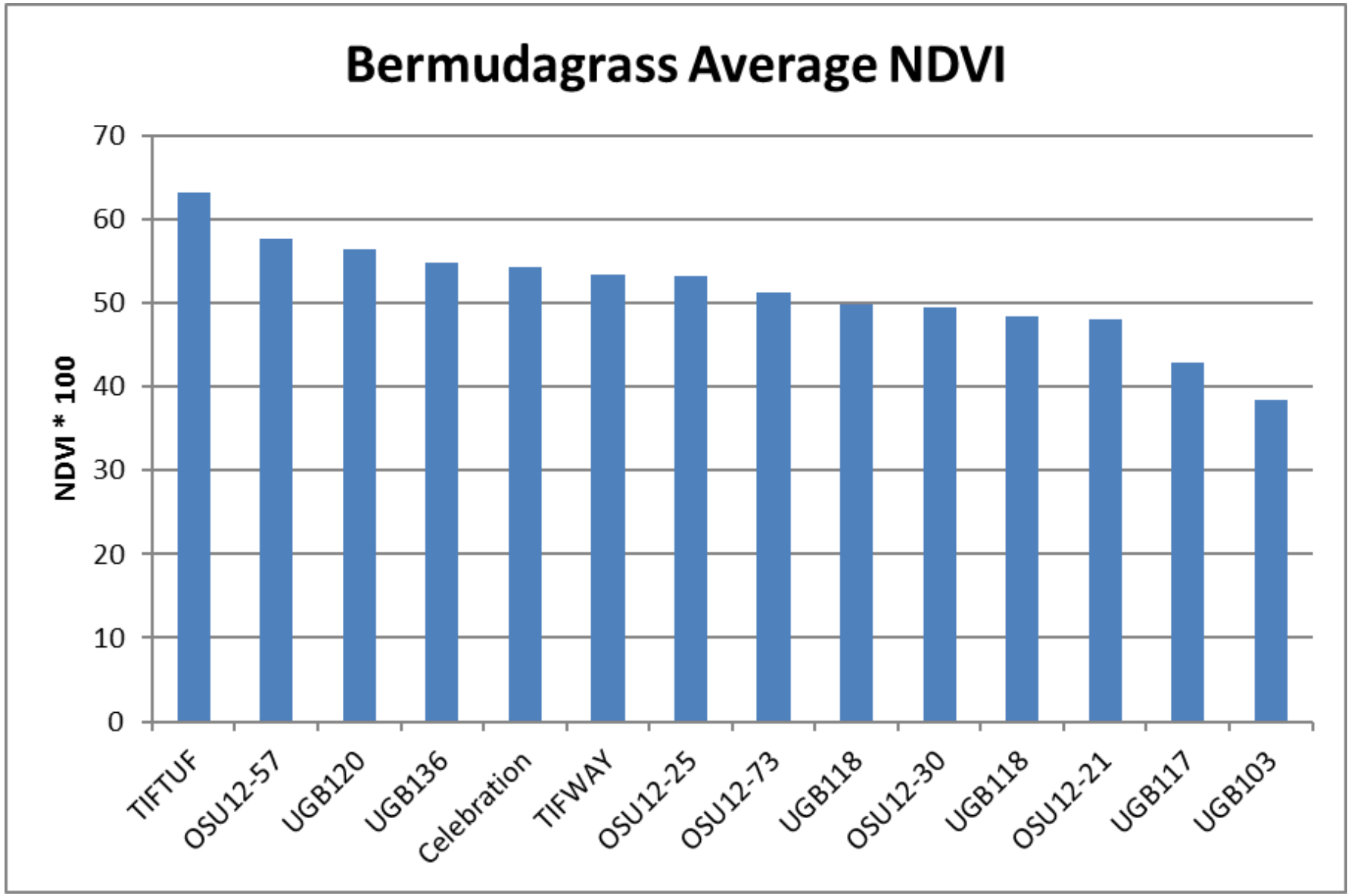
Measurements

- Visual Quality Ratings
- Digital image analysis
- NDVI
- Membrane Stability
- Leaf Hydration Status
- Canopy Temperature
- Osmotic Adjustment
- Respiration Rate
  - Infrared gas analyzer

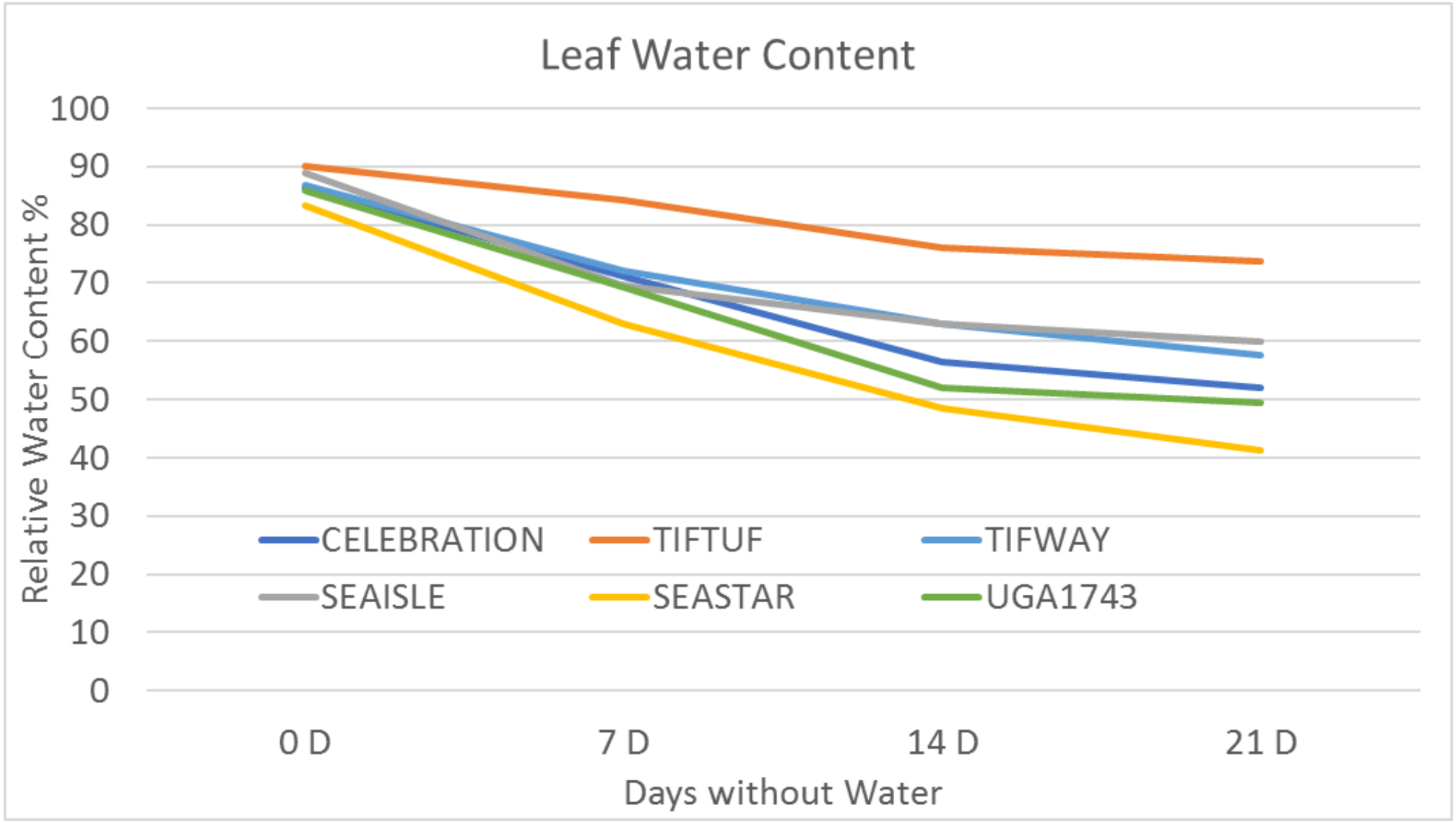


Results

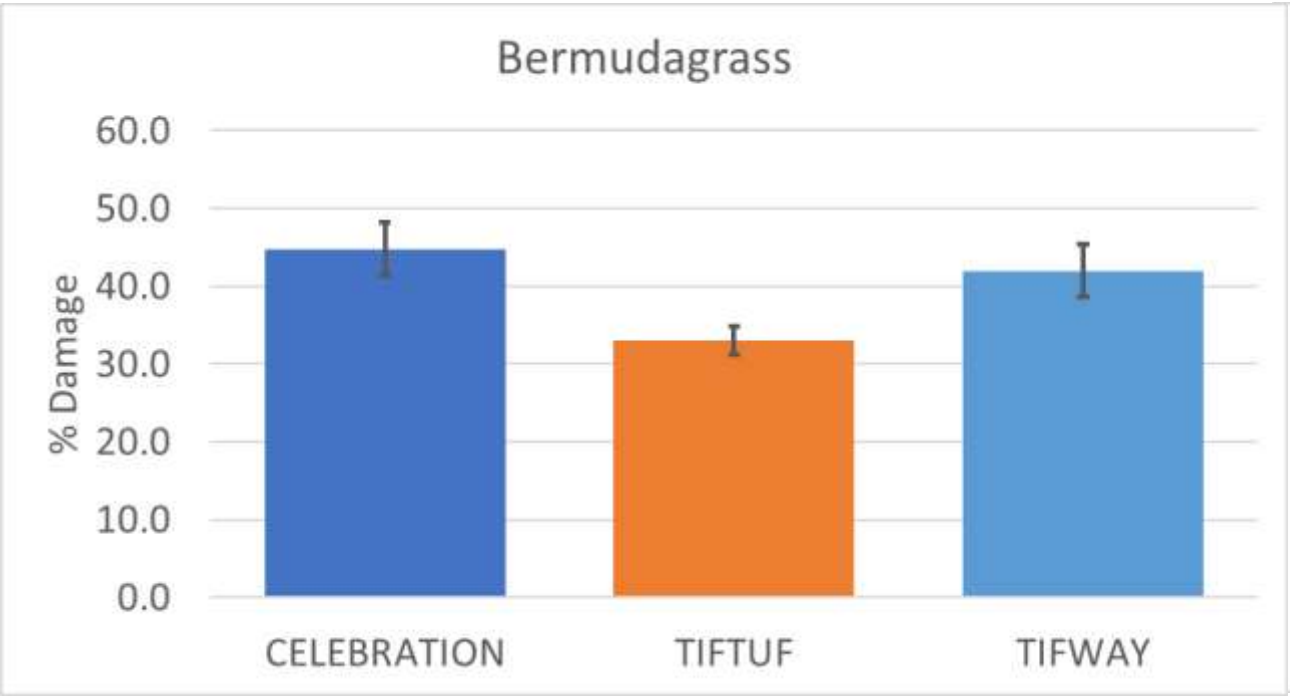
Results: NDVI

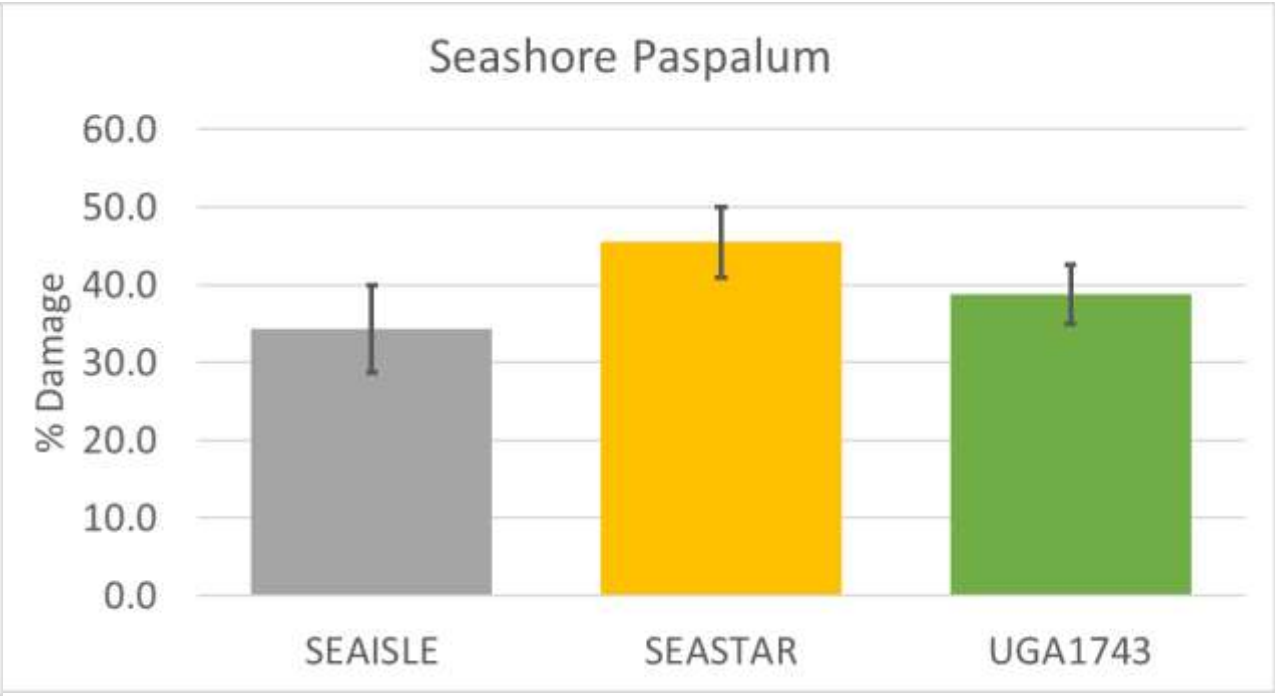


Results: Leaf Water Content

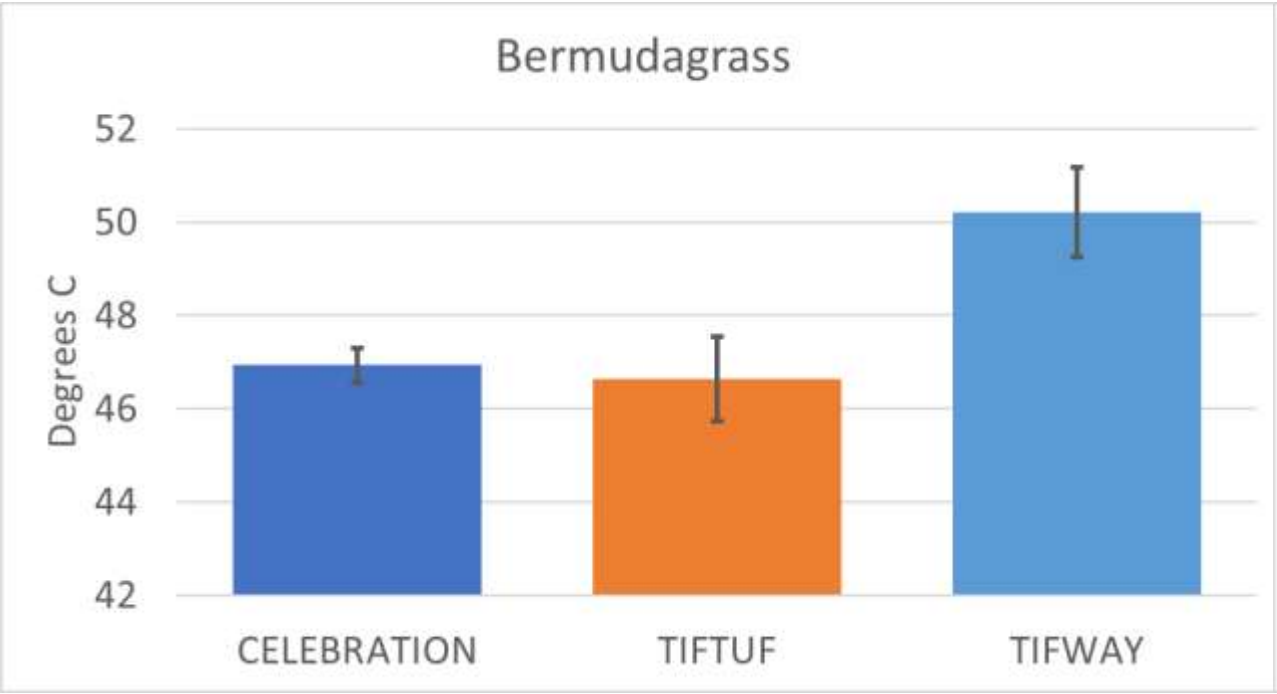


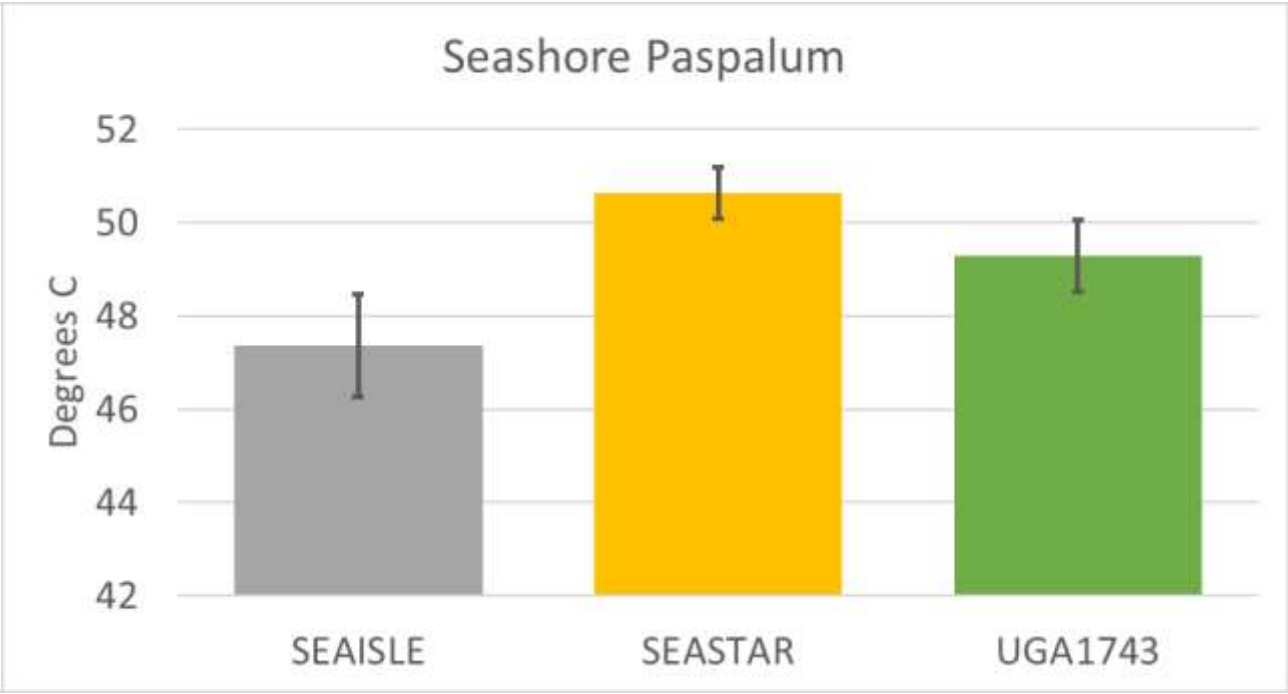
Results: Membrane Stability



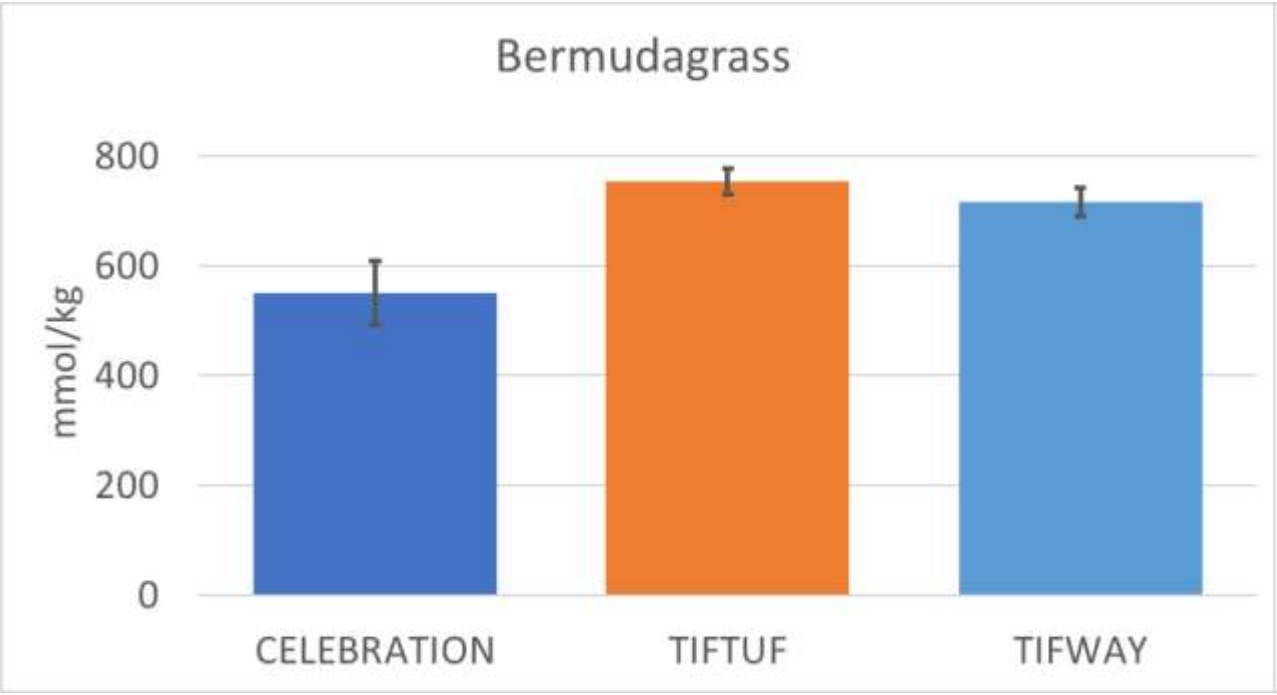


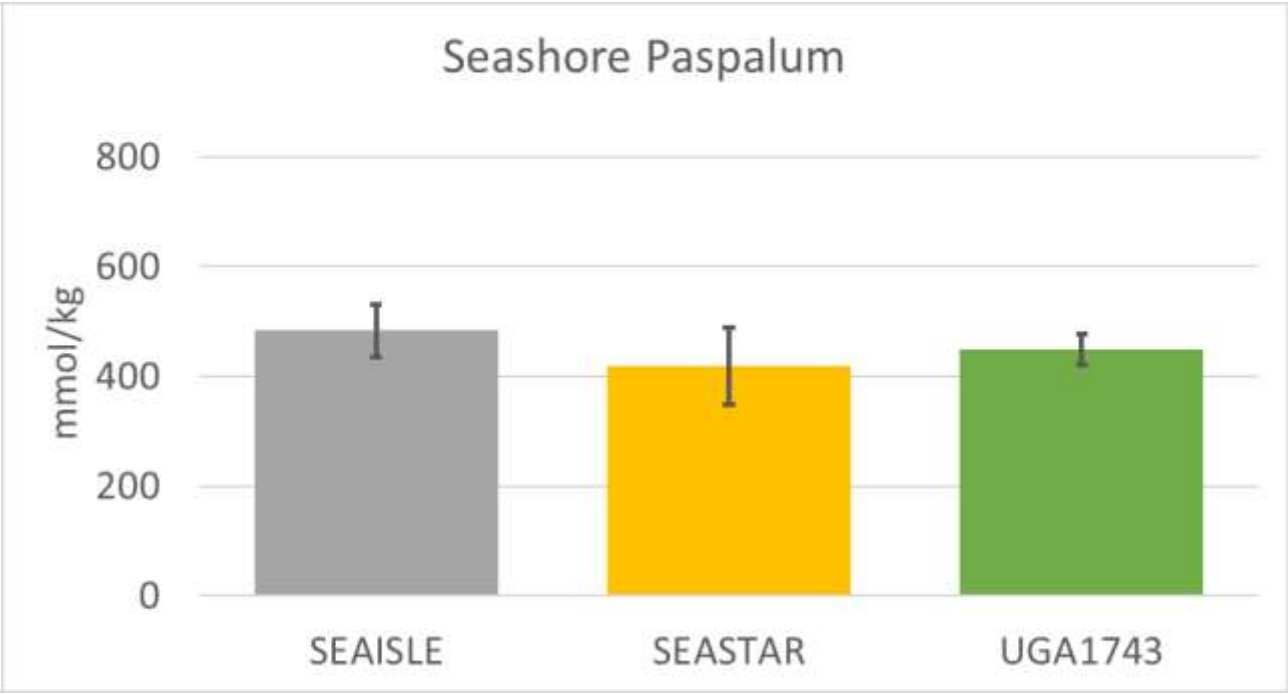
Results: Canopy Temperature





Results: Osmotic Adjustment



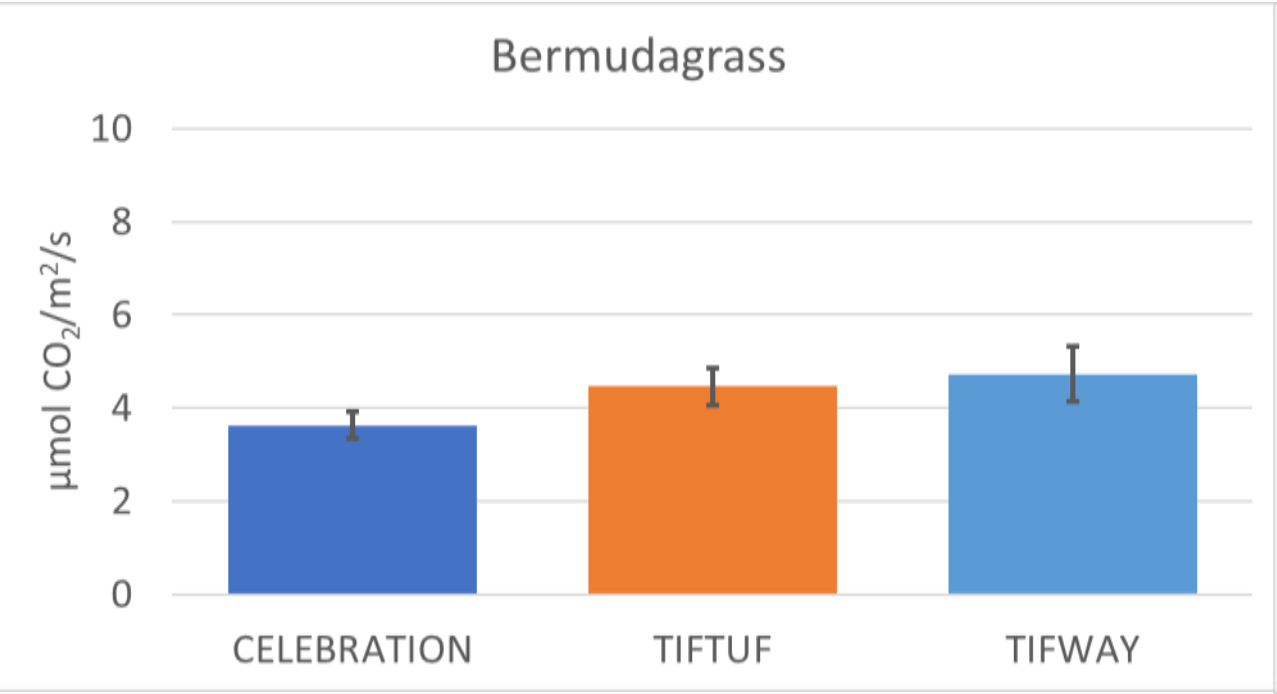


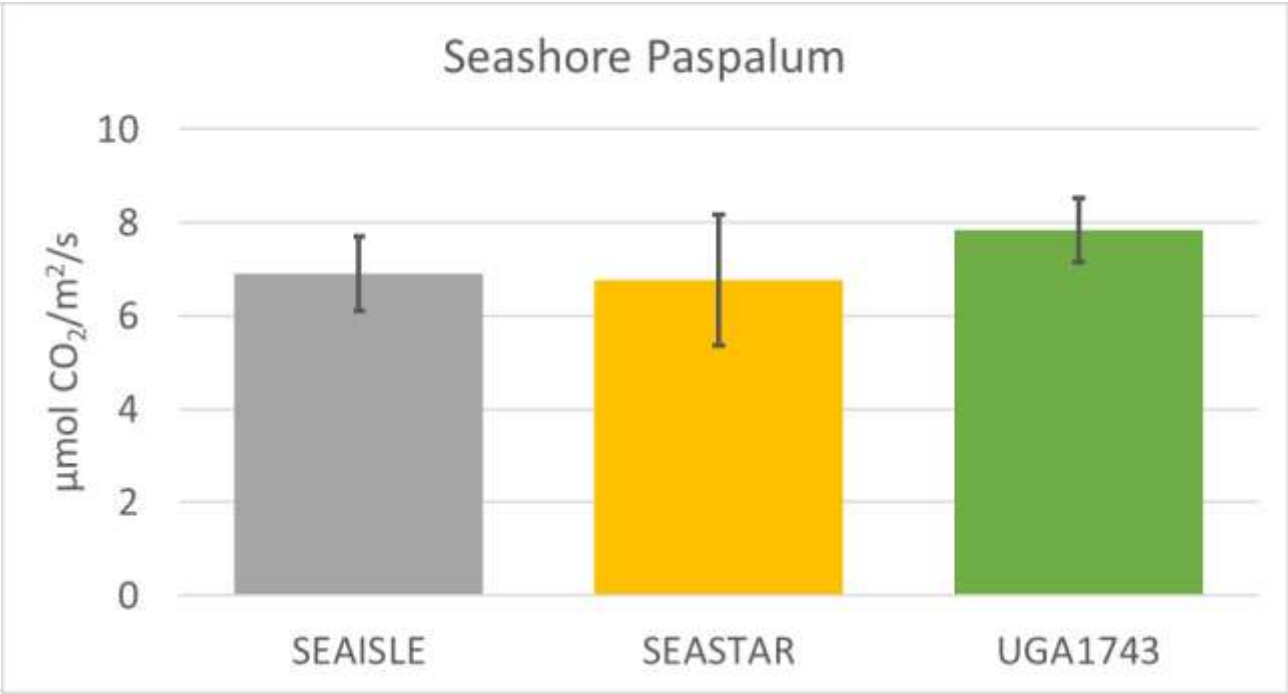
Results: Comparison

TIFWAY

TIFTUF

Results: Respiration





Other Species?

ST. AUGUSTINEGRASS

Conclusions

Summary

- A range of responses to drought were found
- Some experimental lines performed better than released cultivars, others worse
- Different lines may use different mechanism for withstanding drought such as osmotic adjust versus water usage
- More extensive studies are needed to further explore these differences
- Use of multiple mechanisms likely to have greatest drought tolerance levels
- Another round of drought to be performed this year

Future Research

- Continue additional rounds of drought to confirm results
- Identify germplasm with superior drought tolerance
- Determine physiological mechanism regulating drought tolerance and the underlying molecular biology controlling these mechanisms
- Leverage this information into the development of improved cultivars


Thank you!