SOYBEAN AGROECOSYSTEM RESPONSES TO FUTURE HEATWAVES

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Introduction

- **Why soybean?**
  - Annual legume, edible seed
  - Economically the most important bean in the world
  - Can produce at least twice as much protein per acre than any other major vegetable or grain crop
  - Uses
    - Food (soymilk, tofu, soy sauce, etc.)
    - Biofuel
    - Livestock feed
    - Chemical products (paints, adhesive, fertilizers, etc.)

Introduction

- **Soybean Industry 2009**
- U.S. was the world's leading soybean producer and exporter
- U.S. exports approximately 43 % of the soybean production
- U.S. soybean production:
  3.4 billion bushels (estimated)
- Soybean production, top five States (estimated):
  Iowa - 486 million bushels
  Illinois – 430 million bushels
  Minnesota - 285 million bushels
  Indiana - 267 million bushels
  Nebraska - 259 million bushels

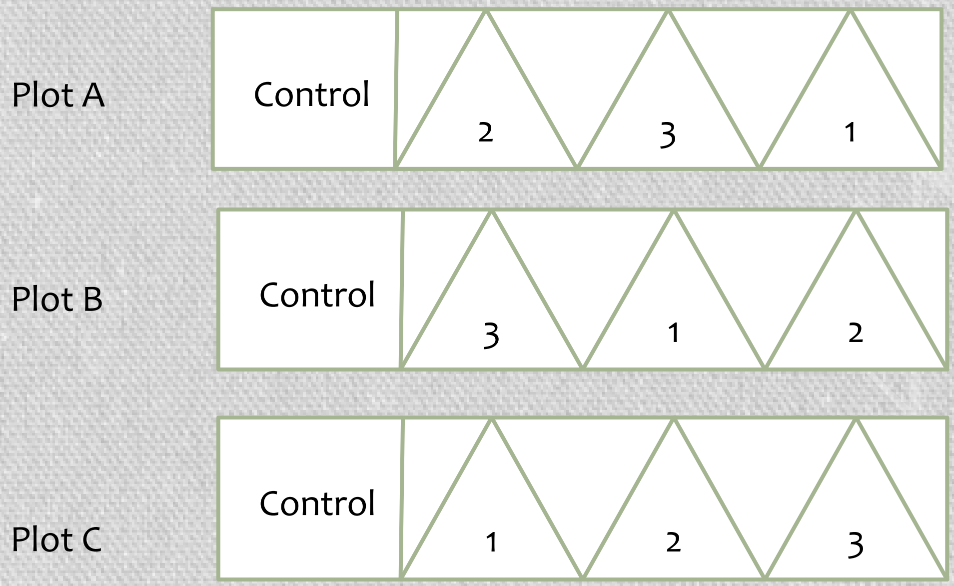
  - Sources: *Crop Production* and *Grain Stocks*, National Agricultural Statistics Service, U.S. Department of Agriculture and *Oilseed Crushings*, Census Bureau, U.S. Department of Commerce.

Introduction

- Earth temperature is rising
- The study of the effects of sustained heating on the ecosystems of the world is necessary so that we might predict and respond to coming changes both large and small spatial scales (Aronson & McNulty, 2009).
- The most likely changes are an increase in the number of hot days and nights (with some minor regional exceptions), or in days exceeding various threshold temperatures, and decreases in the number of cold days, particularly including frosts. These are virtually certain to affect human comfort and health, natural ecosystems and crops (Schneider et al, 2007).
  - Key vulnerability: Timing, Magnitude

hotFACE

- Soybeans were grown in simulated heatwave (HW) conditions Temperature is increased by 6 C for 3 days (min=35 C; max=40 C).
  - **First HW:** Vegetative growth
  - **Second HW:** Early Reproductive growth (Flowering stage)
  - **Third HW:** Late Reproductive growth (Seed filling stage)
- Active warming method- Infrared (IR) lamps



HOW DOES SOYBEAN WATER STATUS RESPOND TO HEATWAVES ?

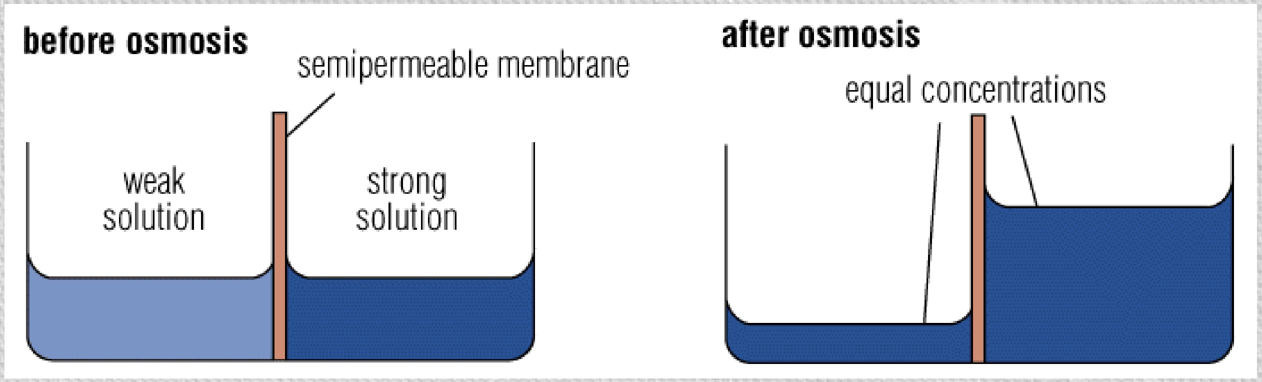
Soil Moisture (SM)
Water Potential (WP)
Osmotic Potential (OP)
Turgor Pressure (TP)

Materials and Methods

- Soil Moisture (SM)
- Volumetric water content (VWC) is the ratio of the volumetric water in a given volume of soil to the total soil volume.
  - Field Scout TDR 300 Soil Moisture Meter
  - Rod Length= 20cm

Definitions

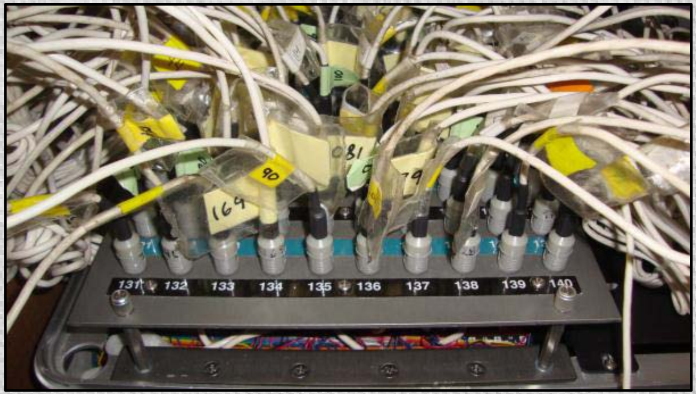
- **Water Potential** (WP)- Chemical potential of water.
  - **Zero** for pure water.
  - Plant cells usually have negative values.
  - Water will move from an area of higher WP to an area of lower WP.
    - WP= OP + TP
- **Osmotic Potential** (OP) – Contribution due to dissolved solutes.
  - Solutes always decrease water potential (make it more negative)
- **Turgor Pressure** (TP)- Pressure build up in plant cells due to cell wall.
  - Increase as water enters a cell
  - Positive values

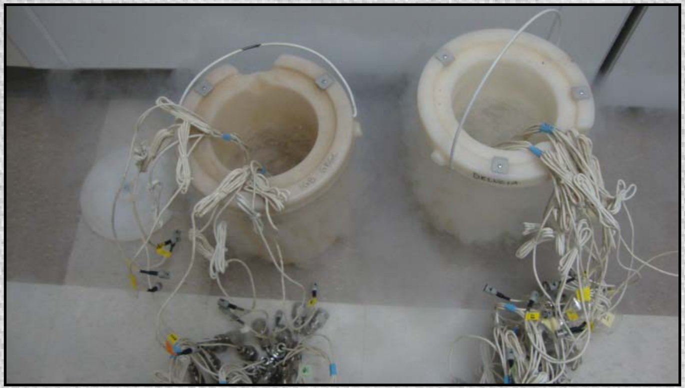


Materials and Methods

- **Water Potential (WP)**
  - Thermocouple psychometers are commonly use to measure plant water status
  - The Chambers are plugged in to CR-7 connection board
  - After equilibrating and obtaining a constant temperature (2-3 hrs approx.), WP is measured
- **Osmotic Potential (OP)**
  - The chambers are submerged in a bucket of liquid nitrogen(N_2) for a few minutes
  - Equilibrate overnight
  - Run again in the CR-7 machine, OP is measured
- **Turgor Pressure (Ψ_P)**

  Ψ_P = WP- OP



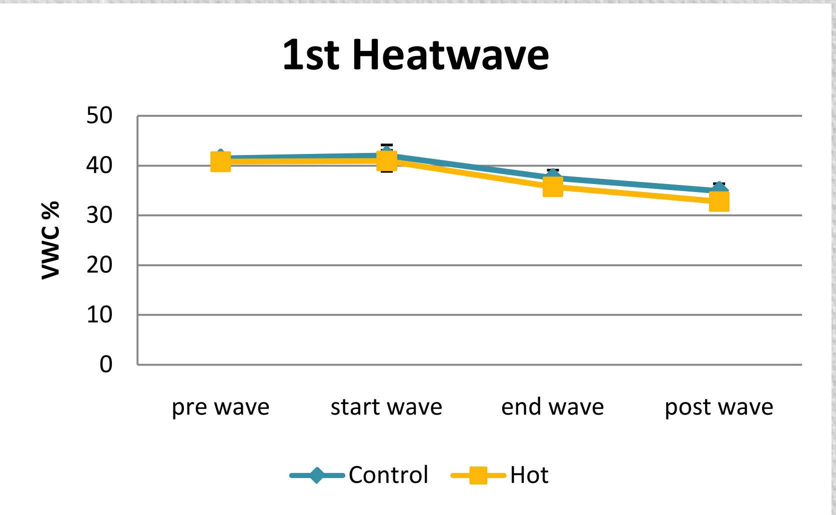


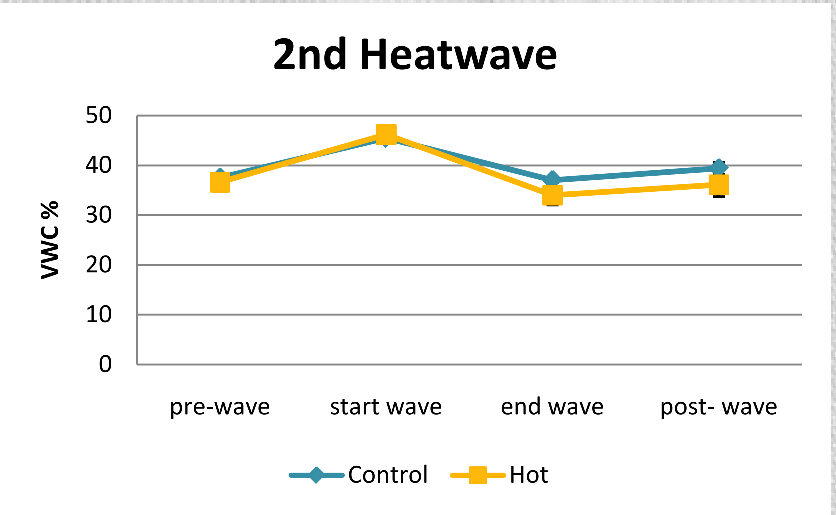
Materials and Methods

- **Days of measurements**

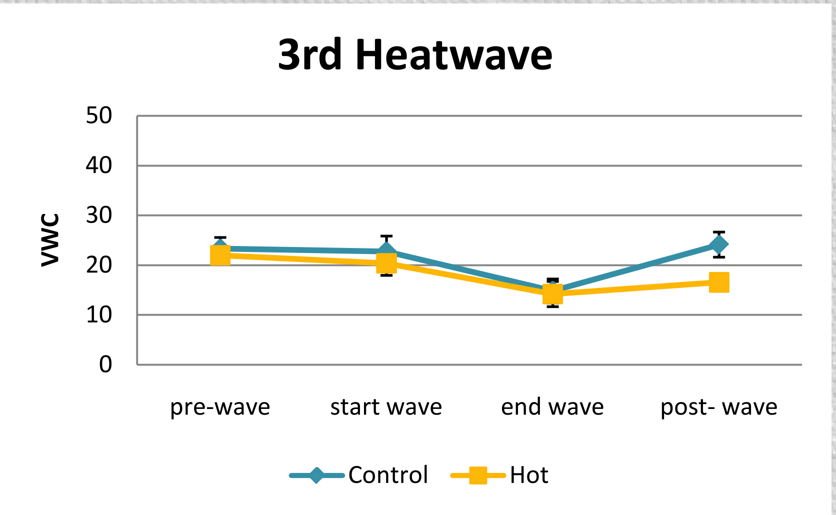
Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
	HW start 5 am			HW end 5 am	
Pre-wave	Start-wave		End- wave		Post- wave

Results: Soil Moisture

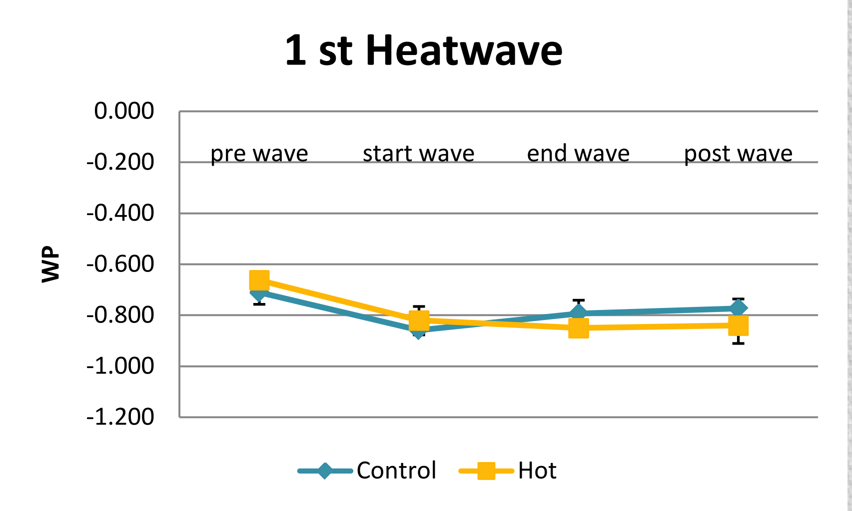


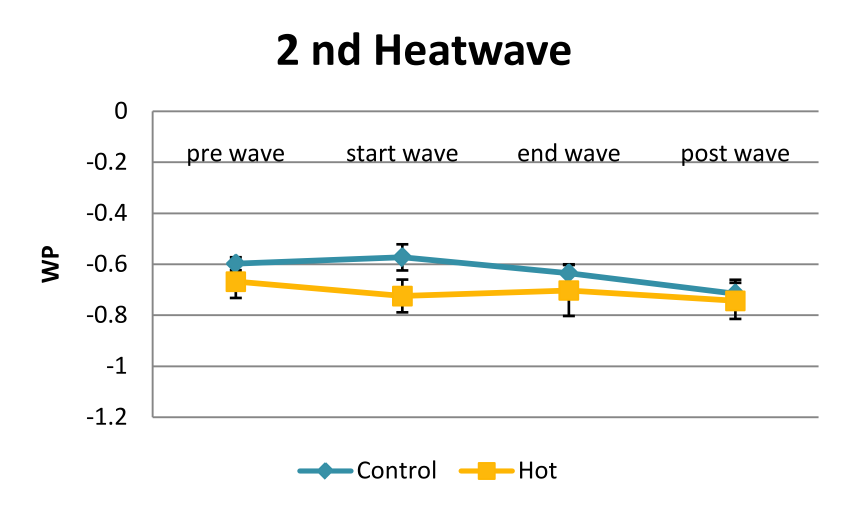


Soil moisture was consistently lower in elevated temperature plots



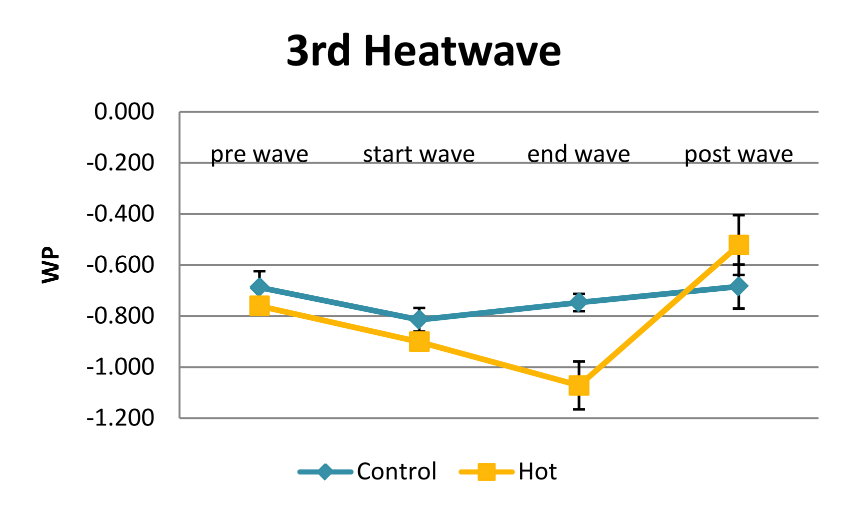
Results: Water Potential



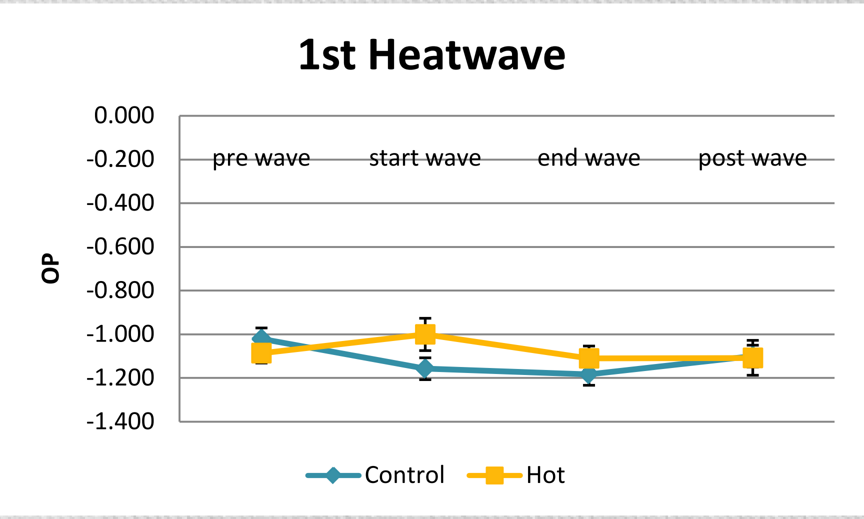


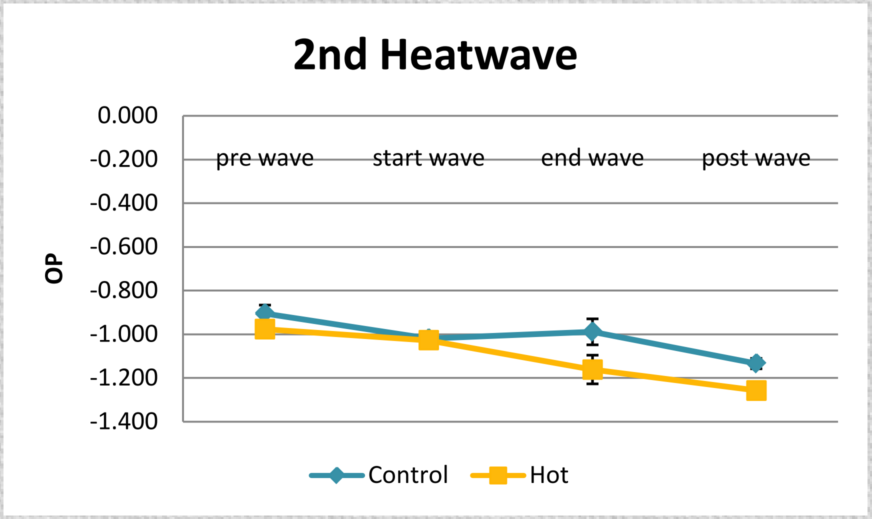
Water potential was consistently more negative in elevated temperature plots

This suggests that plants were more water stressed in elevated temperature plots



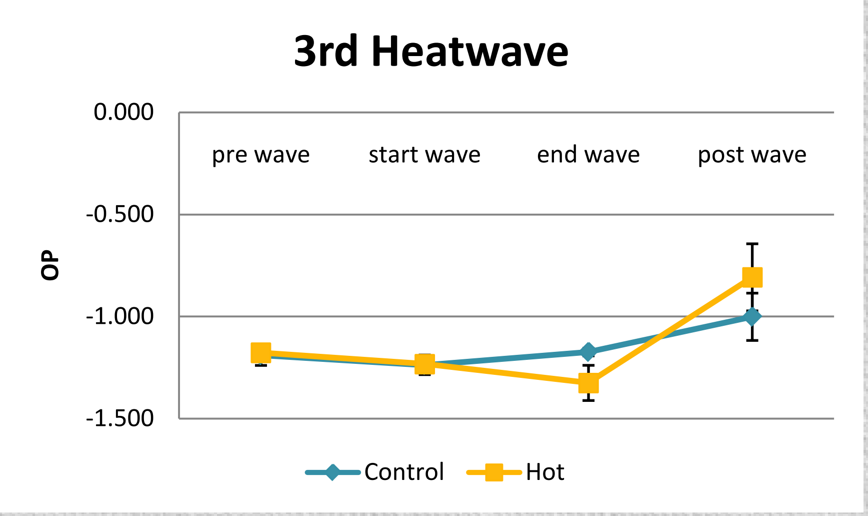
Results: Osmotic Potential



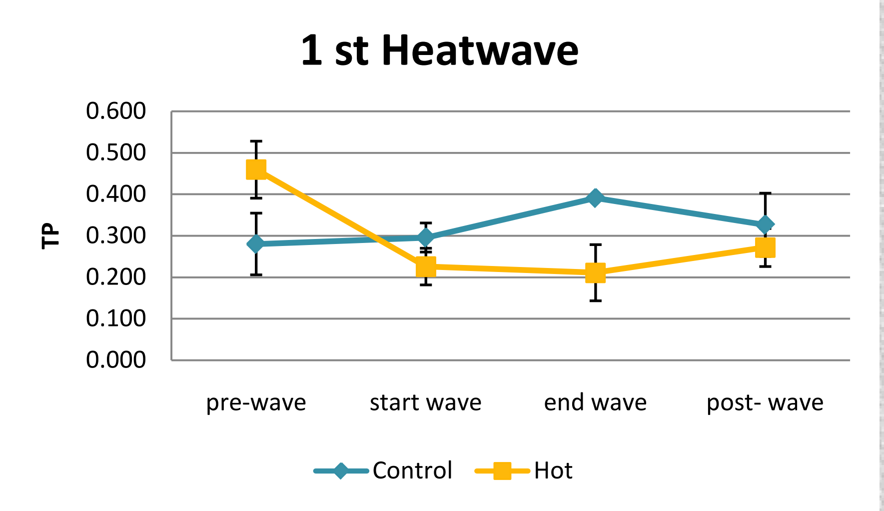


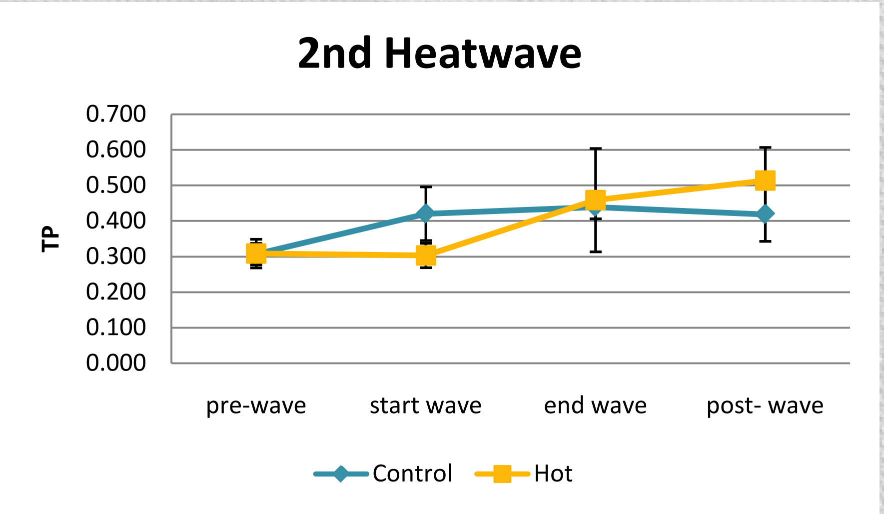
Osmotic potential was most of the time more negative in elevated temperature plots

*** More data is needed to completely understand these behavior**

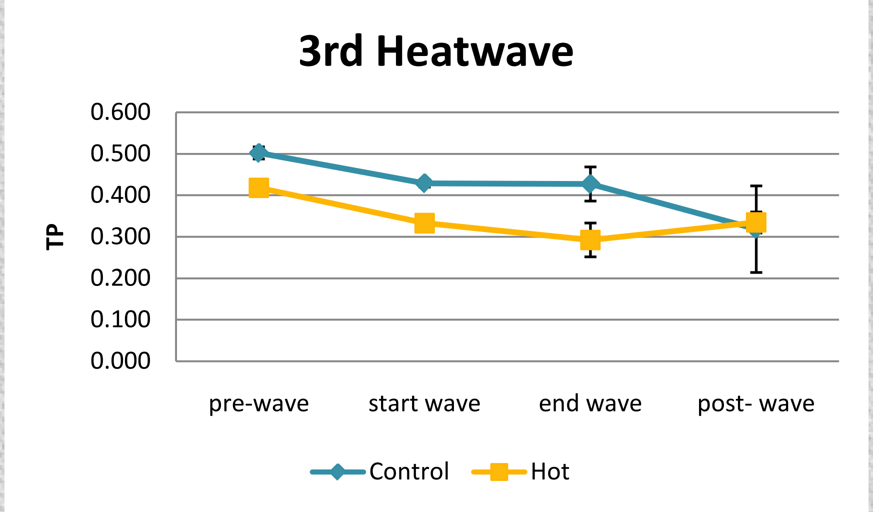


Results: Turgor Pressure





Turgor pressure was most of the time lower in elevated temperature plots



Conclusion

- Plants under elevated temperature were more water stressed than the control group
- The difference in soil moisture is not sufficiently significant to cause a big water stress on plants
- Therefore it is inferred that the major source of water stress in plants is the increase of temperature
- It is likely that increased water stress will play an important role in future crop productivity (quality, size, etc.) but more data is needed
- For an accurate analysis of osmotic potential and turgor pressure, additional data (i.e. photosynthesis rate) is required

Acknowledgments

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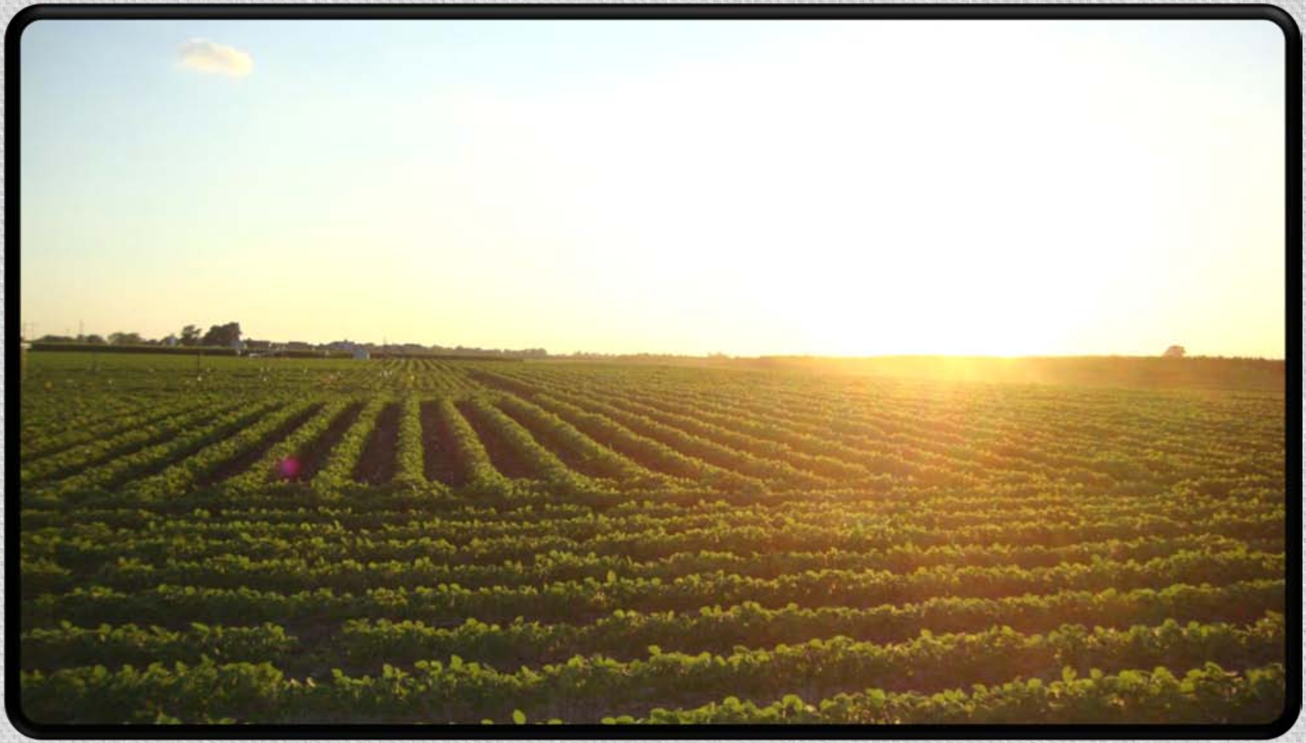

Questions ?

Reference

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- Schneider, S.H., S. Semenov, A. Patwardhan, I. Burton, C.H.D. Magadza, M. Oppenheimer, A.B. Pittock, A. Rahman, J.B. Smith, A. Suarez and F. Yamin, 2007: Assessing key vulnerabilities and the risk from climate change. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 779-810.