

# Beat the Heat: Promising Strategies to Reduce Heat Damage in Raspberry

**Lisa Wasko DeVetter**, G. Munashe Makonya, David R. Bryla, Michael Hardigan, Wendy Hoashi-Erhardt, Troy Peters, Suzette Galinato, and Karina Gallardo



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# Pacific Northwest Raspberry



Mediterranean climate has historically been ideal for growing high quality fruits for fresh and processed markets





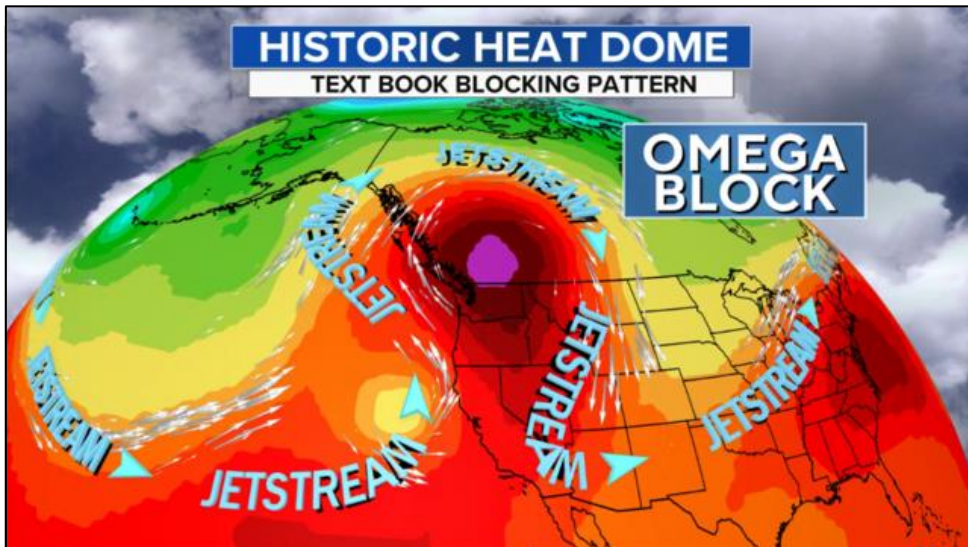
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# Heat Events are on the Rise

AP WORLD U.S. POLITICS SPORTS ENTERTAINMENT BUSINESS SCIENCE FACT CHECK ODDITIES HEALTH VIDEO CLIM

Election Day Israel-Hamas war Rashida Tlaib Carson Wentz Hunter Biden case

## NW Washington raspberry harvest down 30% due to heat wave



- Increasing temperatures in a traditionally mild climate
- Catalyst → heat dome of 2021
  - 47°C led to 30-40% crop loss
  - Some total crop loss
  - ~\$20 million loss in revenue



# Response → “Beat the Heat” Project

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**Lisa DeVetter**

Washington State University Associate Professor of Horticulture specializing in small fruits.



**Givemore Munzhe Makonyi**

Washington State University Postdoctoral Fellow researching physiological and genetic mechanisms that contribute to red raspberry's heat tolerance.



**David Bryla**

Research Horticulturist at the USDA-ARS Horticultural Crops Research Unit.



**Wendy Hoashi-Erhardt**

Washington State University Director of the raspberry breeding program and plant breeder.



**Michael Hartigan**

USDA-ARS Horticultural Crops Research Unit Research Geneticist and Plant Breeder.



**Mohamed Abdou Yousef**

Ain Shams University, a teaching assistant at the Agricultural Engineering Department. He specializes in irrigation and drainage engineering.



**Troy Peters**

Washington State University Professor in the department of Biological Systems Engineering. His focus is on irrigation and irrigation efficiency.



**Suzette Calinato**

Washington State University Assistant Director of IMPACT Center in the School of Economic Sciences.



**Karina Gallardo**

Washington State University Professor and Extension Specialist at the School of Economic Sciences. Her program's focus is advancing agribusiness opportunities for specialty crops.



**Chris Benedict**

Washington State University Regional Extension Specialist.



**Maria Zamora Re**

Oregon State University Assistant Professor at the Geological and Ecological Engineering Department. She specializes in irrigation extension and agricultural water management.

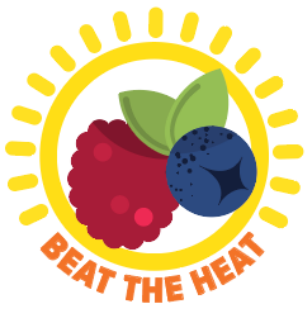


**Margaret McClothern**

Washington State University, 2023 CAU INRS Undergraduate Intern. Maggie developed outreach materials.



- Multi-institutional team of researchers, extension specialists, and students
- Expertise: horticulture, physiology, engineering, breeding, economics, extension



# Project Objectives

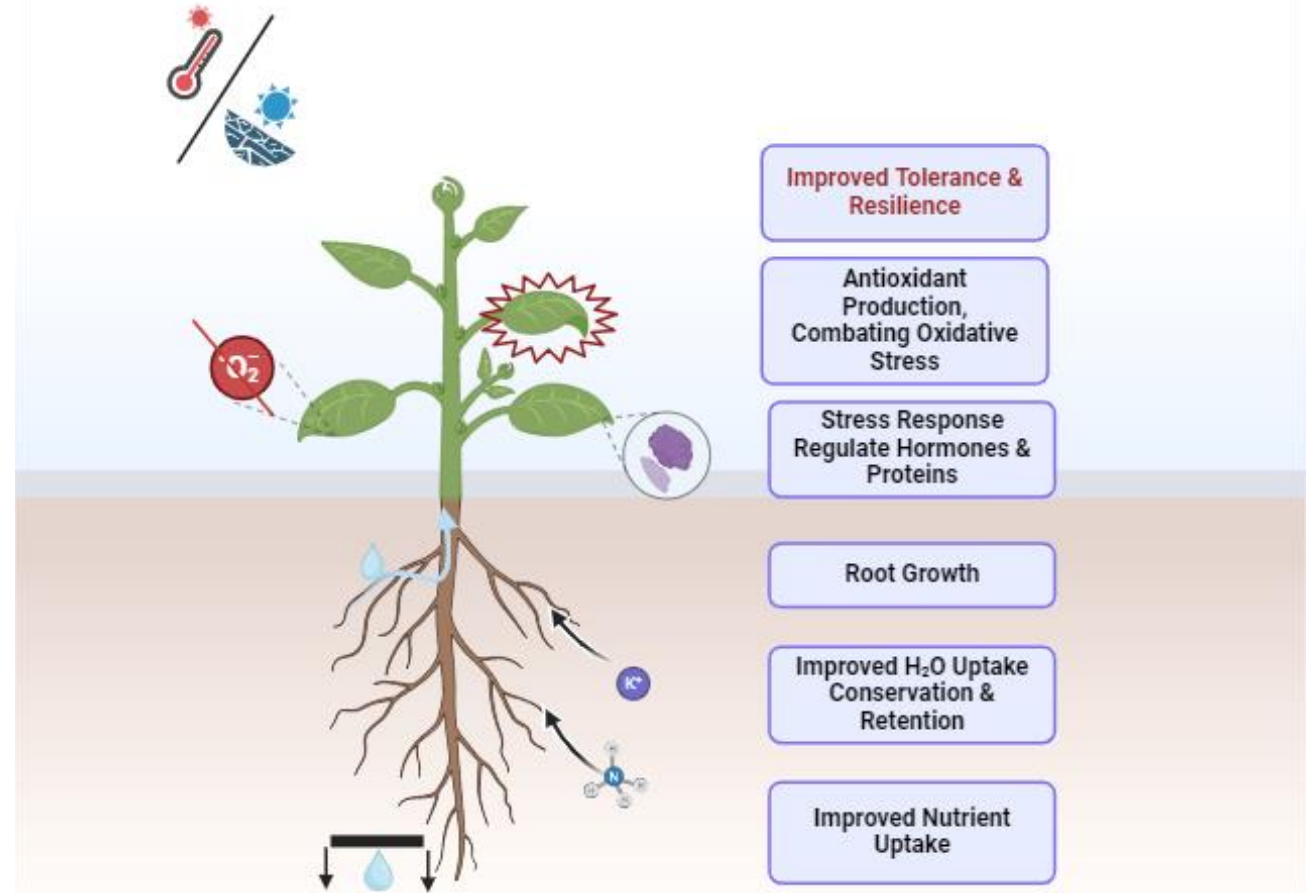
1. Evaluate the impacts and cost-benefits of heat mitigation technologies across several cultivars and promising selections of raspberry
  - *Heat protectants*
  - *Evaporative cooling and shade cloth*
2. Examine the physiological and genetic mechanisms that contribute to heat tolerance across cultivars and advanced selections of raspberry
3. Effectively disseminate project information to growers and the supporting agricultural research, crop consulting, and Extension community

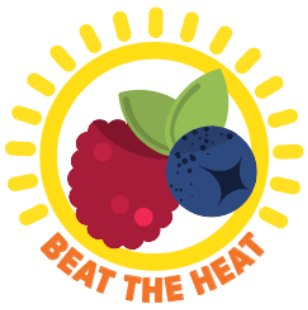




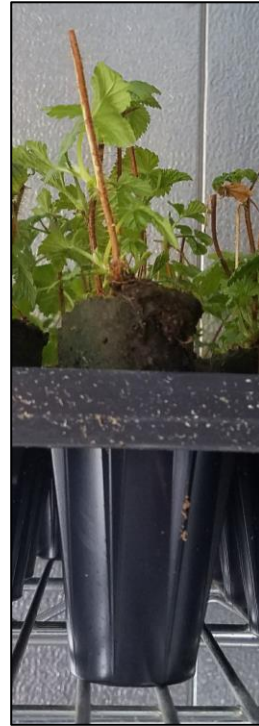
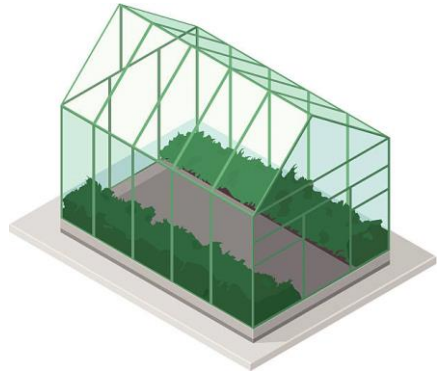
# Heat Mitigation Using Protectants

- Heat protectants or “biostimulants” are a more immediate potential solution to mitigate heat stress
- Includes osmolytes (e.g., proline and glycine betaine), phytohormones, signaling molecules, trace elements (e.g., Si), and clear and edible particle films
- Research is limited...





# Heat Protectant Trial



- 'Meeker' (control)
- WSU 2188 (WSU)
- ORUS 4715-2 (USDA-ARS)



500g/pot



5g/pot

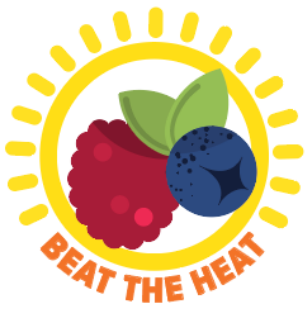


3g/pot



100% FC

WSU IAREC  
Prosser, WA  
June - Sept '23



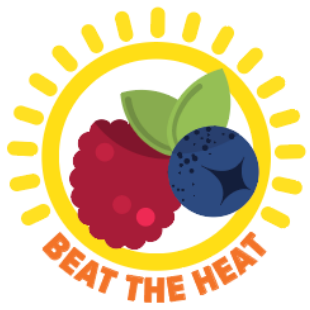
# Experimental Design + Treatments

Treatments*	Application rate		Primary ingredients
	Foliar	Soil	
Control (untreated)	-	-	-
FRUIT ARMOR	1g L <sup>-1</sup>	5.2 g L <sup>-1</sup>	97% glycine betaine
Optysil	1 mL L <sup>-1</sup>	2.5 mL L <sup>-1</sup>	200 g SiO <sub>2</sub> and 24 g Fe in 1 dm <sup>3</sup>
KelpXpress	1 mL L <sup>-1</sup>	2.5 mL L <sup>-1</sup>	Kelp ( <i>Ascophyllum nodosum</i> ) extract with protein hydrolysate, KH <sub>2</sub> PO <sub>4</sub> , and Fe EDTA (2N–4P–3K–0.13Fe)

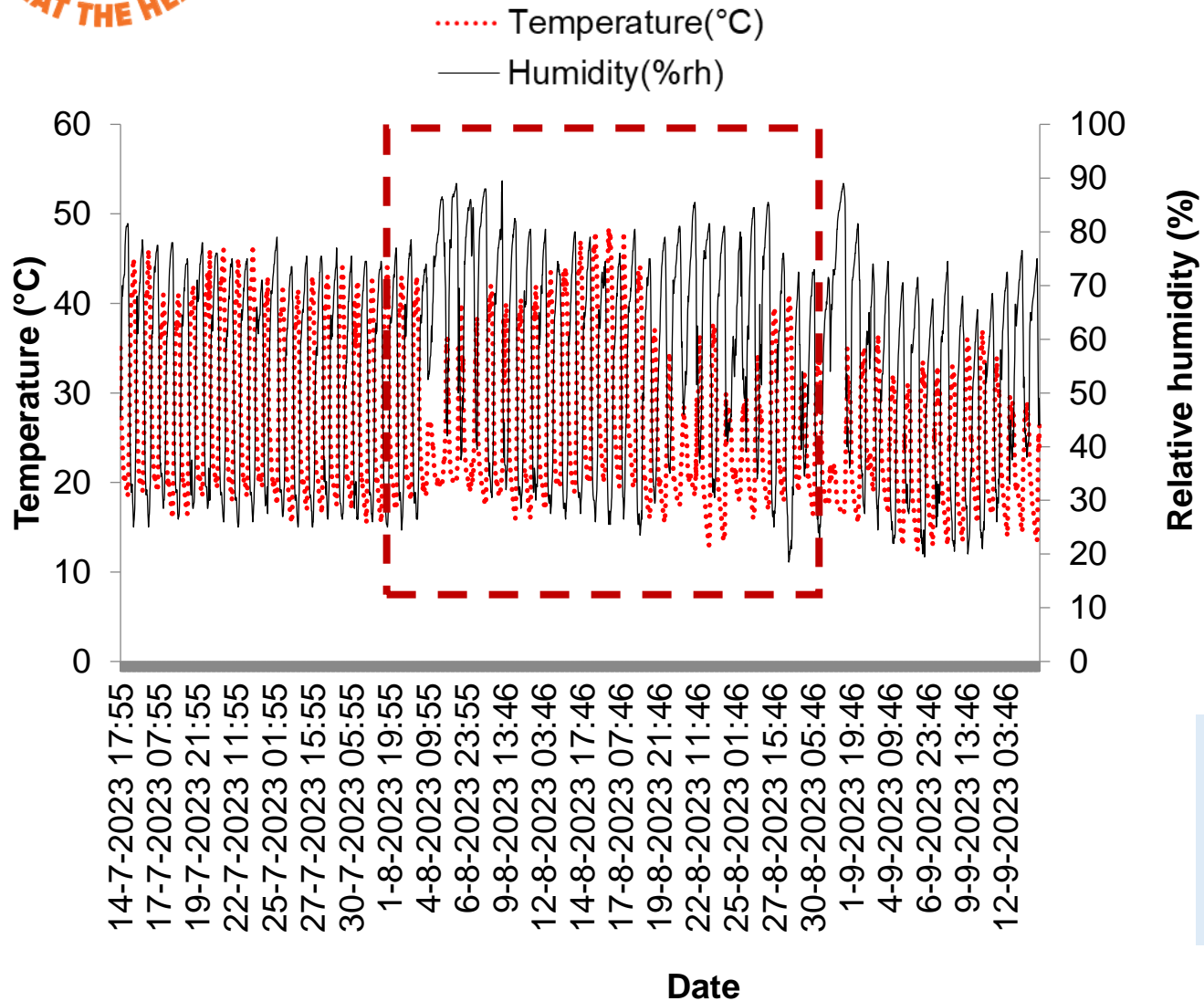
\*Mention of trade names does not mean endorsement. Products manufactured by JR Simplot (Boise, ID, USA).

- Factorial experiment (3 raspberry genotypes and 3 biostimulants + H<sub>2</sub>O control)
- Applied weekly during experiment
- Weekly data collection on physiological variables and biomass

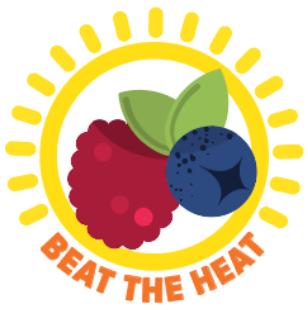




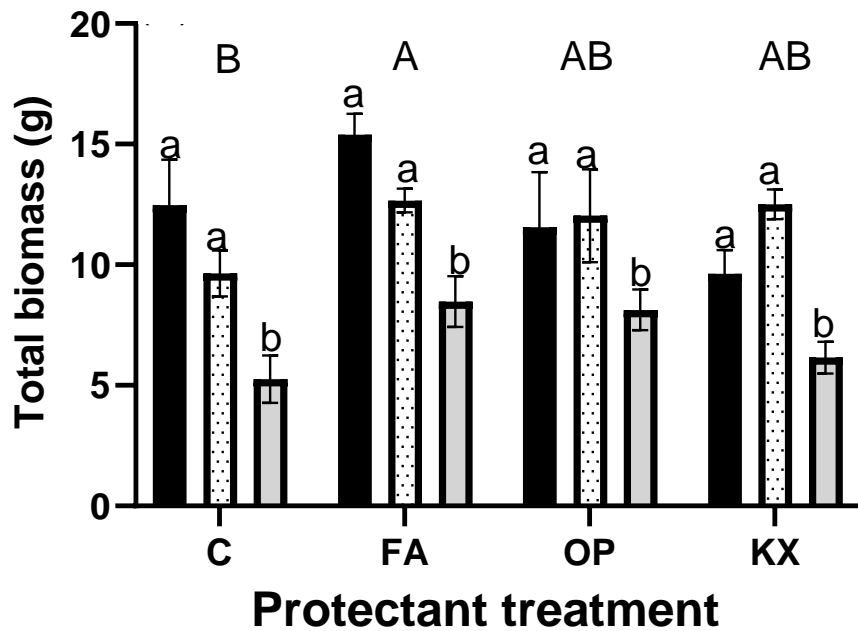
# Glasshouse Conditions



Boxed area represents time between the first treatment application and final day of data collection

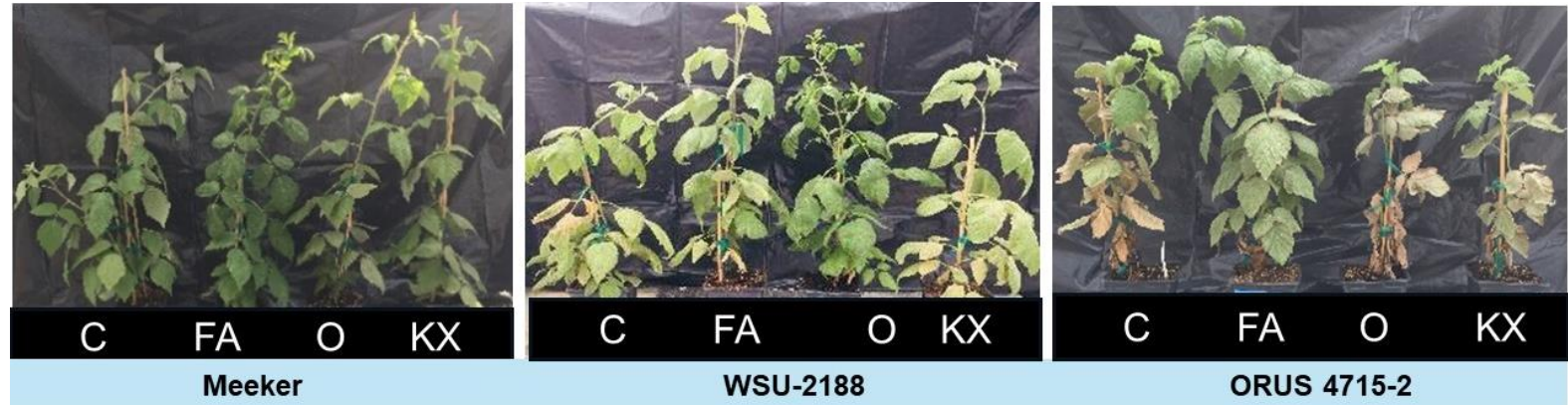


# Biomass

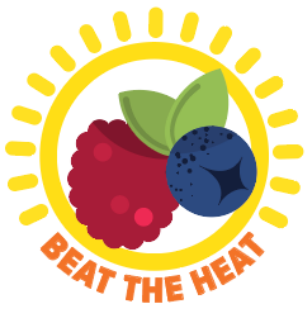


*Different lower- and upper-case letters indicate significant differences between genotypes and protective treatments, respectively.*

■ Meeker  
 ■ WSU 2188  
 ■ ORUS 4715-2

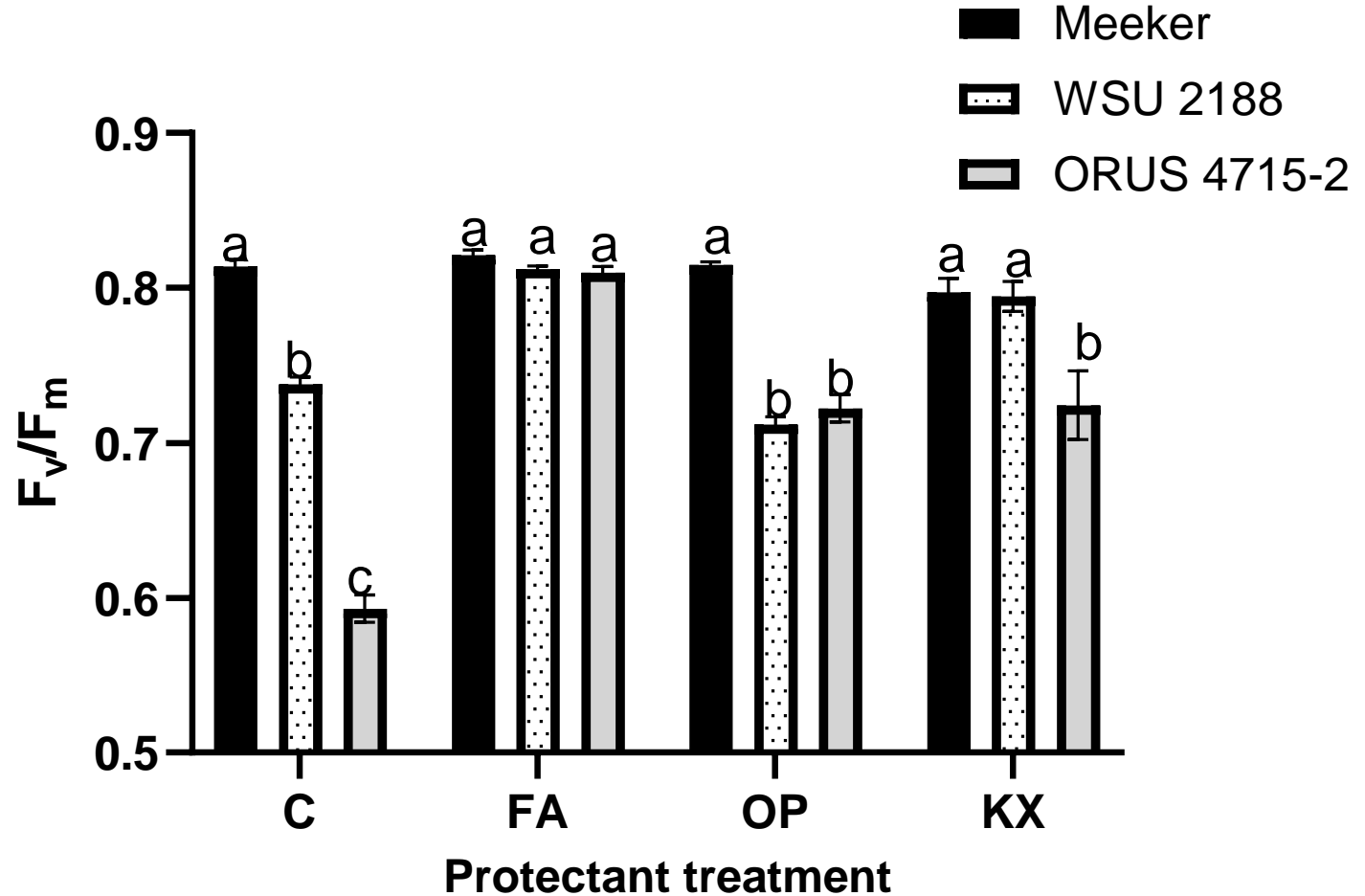


- Total biomass was greatest for 'Meeker' and WSU 2188
- Fruit Armor (FA, glycine betaine) increased biomass compared to the untreated control



# Chlorophyll fluorescence ( $F_v/F_m$ )

- 'Meeker' had greater  $F_v/F_m$  under control and across all treatments
- Fruit Armor (FA, glycine betaine) maintained  $F_v/F_m$  across all genotypes
- KelpXpress (KX) led to greater  $F_v/F_m$  in 'Meeker' and WSU 2188 only





# Conclusions and Next Steps

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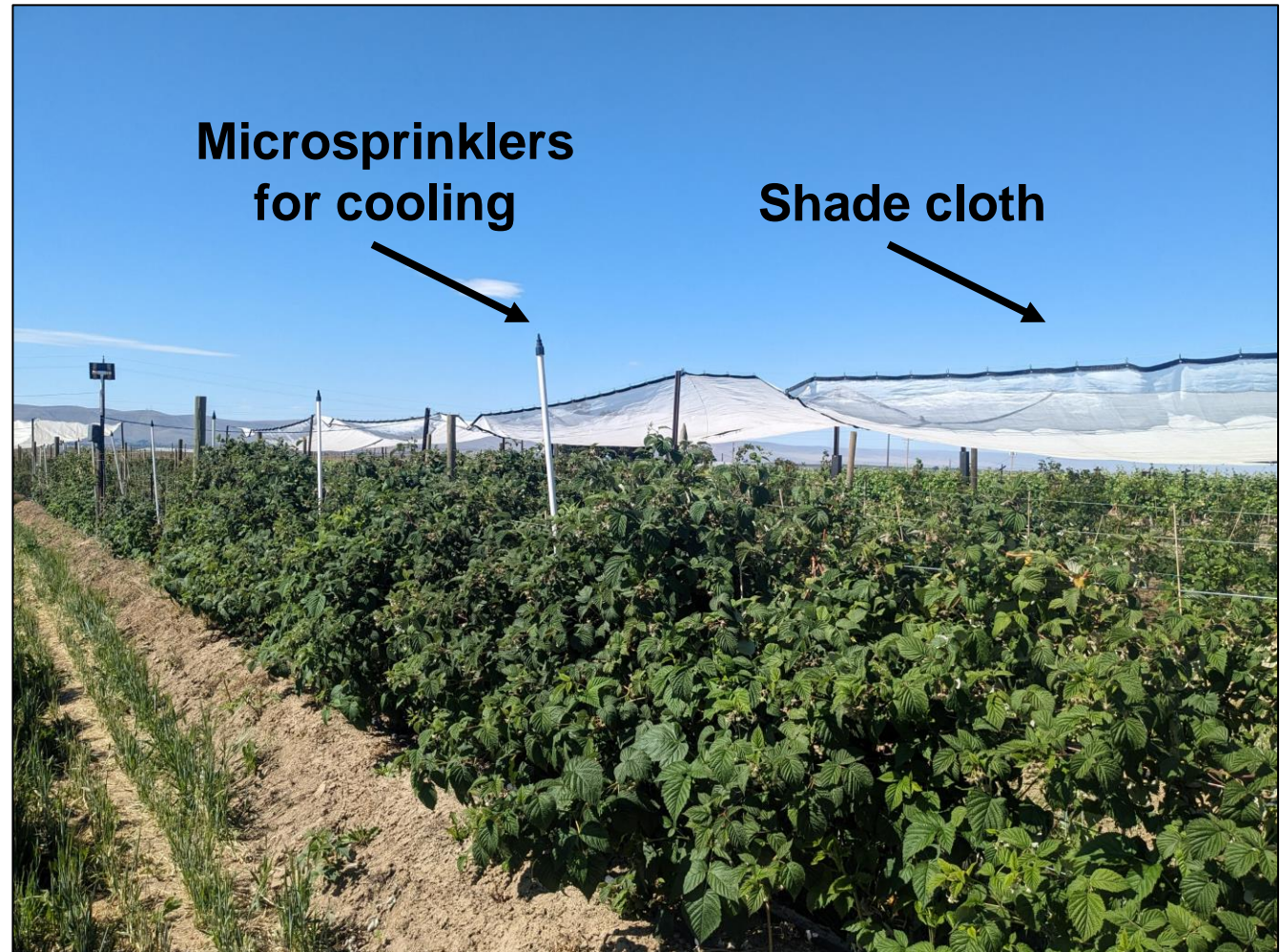


- ‘Meeker’ demonstrated greater thermotolerance
- Glycine betaine in Fruit Armor led to improved thermotolerance:
  - Increased biomass compared to control
  - Improved photosynthetic parameters and maintenance of photochemistry
  - Greater anthocyanins in ‘Meeker’ and WSU 2188
- Kelp was comparable to glycine betaine
- Next steps → field trials evaluating application rates, timing (growth stage), and methods of application



# Heat Mitigation Using Evaporative Cooling and Shade Nets

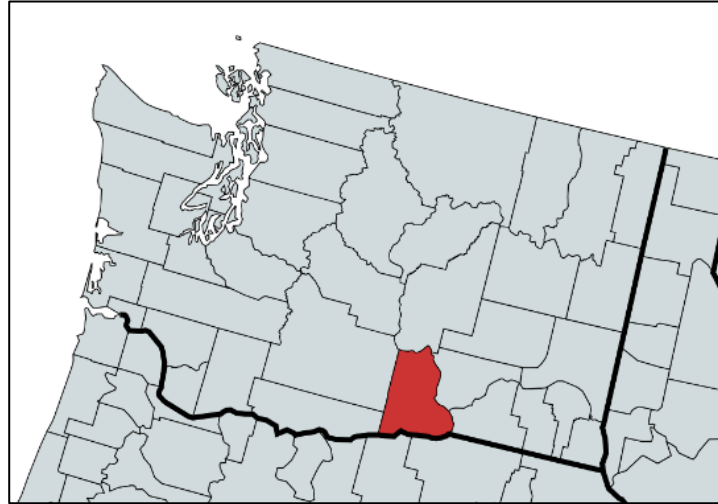
- Heat protectants are still an “unproven” technology
- Evaporative cooling and shade cloth are more established techniques to mitigate heat
- However, research on these technologies for raspberries is limited



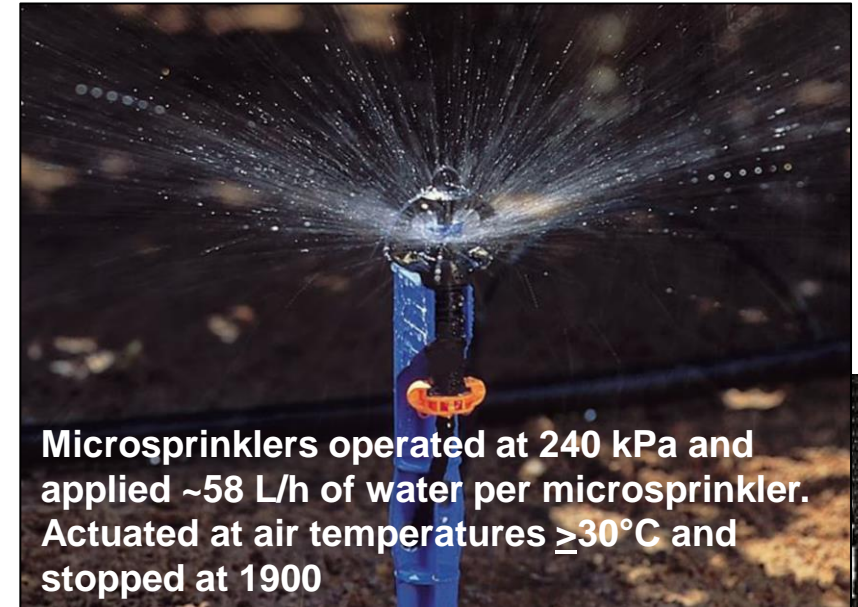
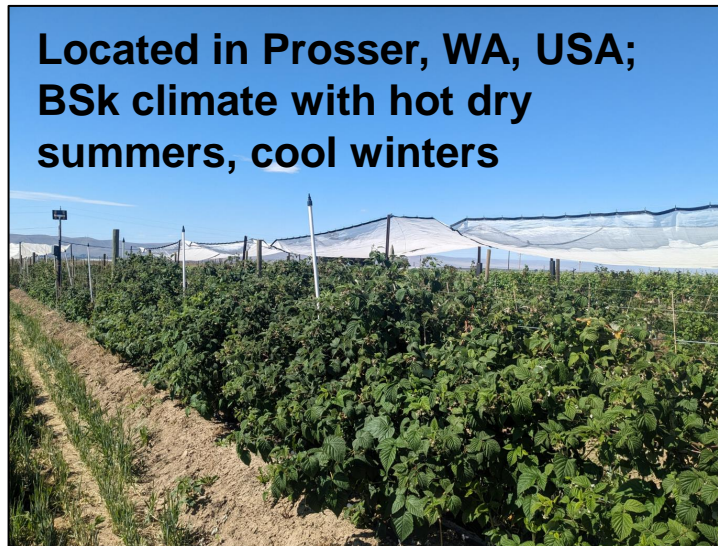


# Experimental Design + Treatments

- Planted in Spring 2023
- Split-plot design
- 4 replications
- 11 plants per split plot
- Main plot (treatment):
  - Evaporative cooling
  - Shade cloth
  - Control (untreated)
- Split plot (genotype):
  - Meeker
  - WakeField
  - WSU 2188
  - ORUS 4715



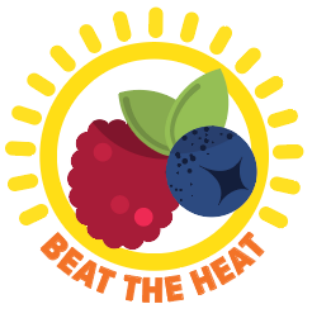
**Located in Prosser, WA, USA;  
BSk climate with hot dry  
summers, cool winters**



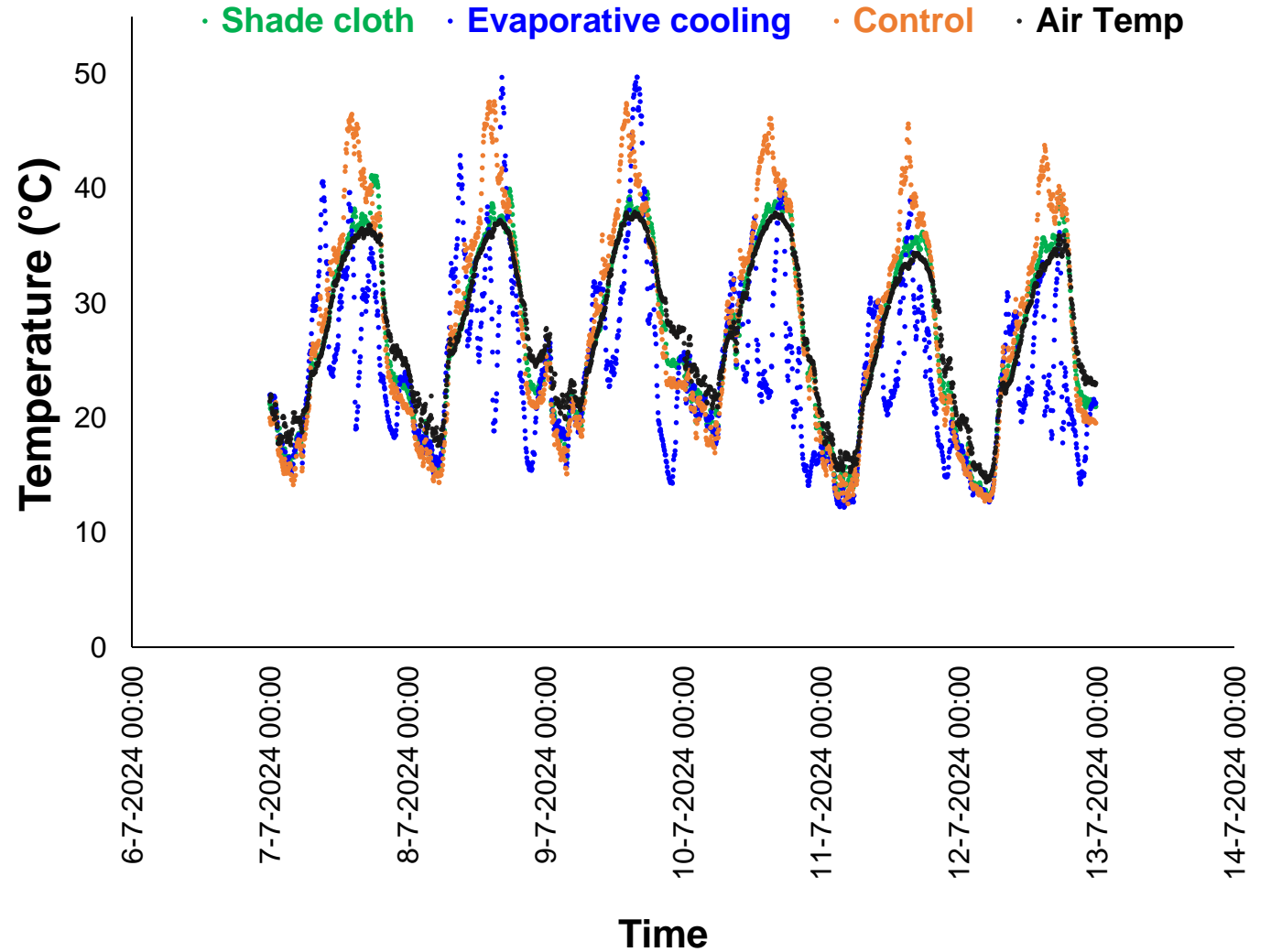
**Microsprinklers operated at 240 kPa and  
applied ~58 L/h of water per microsprinkler.  
Actuated at air temperatures  $\geq 30^{\circ}\text{C}$  and  
stopped at 1900**

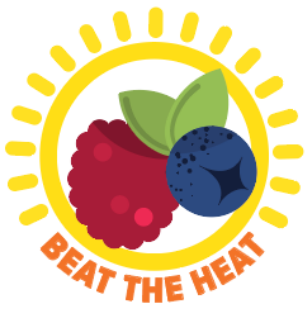


**Shade cloth (40% PAR) installed  
during growing season**



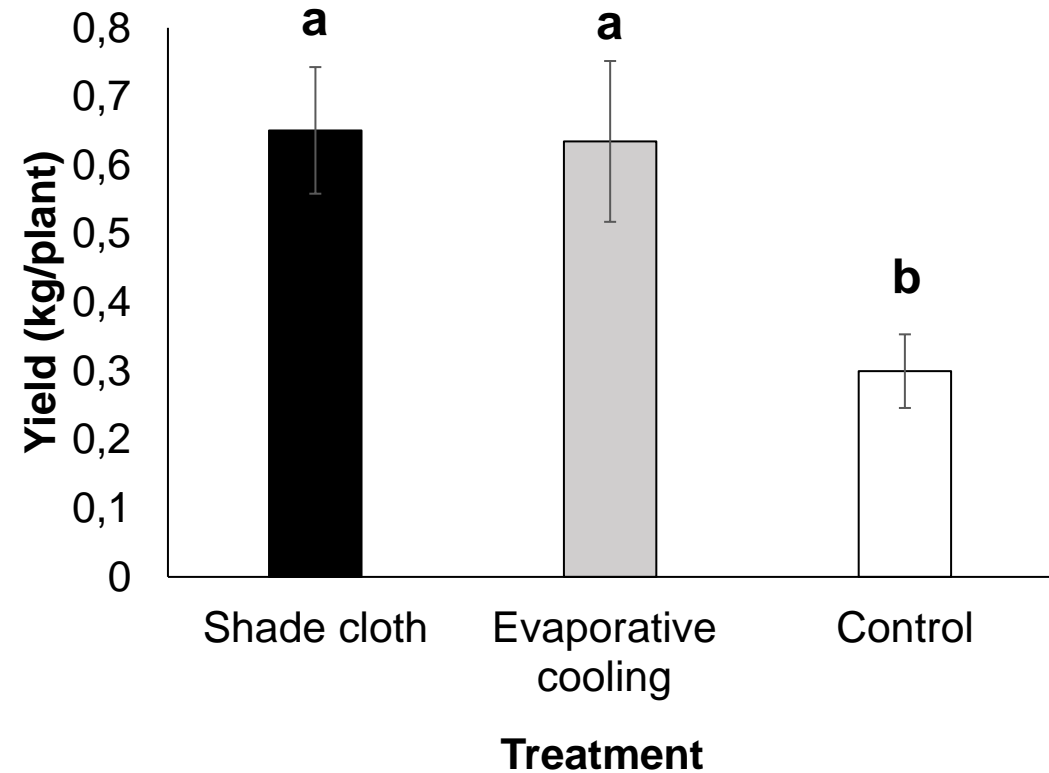
# Fruit Surface and Air Temperatures



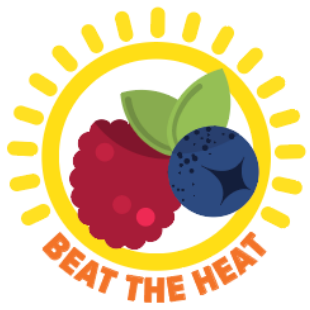


# Yield and Fruit Quality

- No treatment x genotype interaction
- Shade and evaporative cooling increased yield by ~72% relative to the untreated control
- Visible increase in postharvest pathogens after 2 weeks of storage with evaporative cooling for ORUS 4715 only (*'Meeker'* not evaluated)
- Additional fruit quality work pending







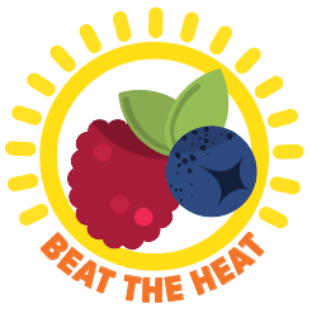
# Stem Water Potential



- No treatment x genotype interaction
- Shade resulted in less negative stem water potential, indicating better hydration status

Treatment	Stem water potential (MPa)		
	June	July	Aug.
Shade cloth	-0.59 b <sup>i</sup>	-0.81 c	-0.79 c
Evaporative cooling	-0.69 a	-0.92 b	-0.92 b
Control	-0.74 a	-0.99 a	-0.99 a

<sup>i</sup>Means followed by a different letter within a column are significantly different at  $P < 0.05$  using a Tukey's honestly significant difference test.

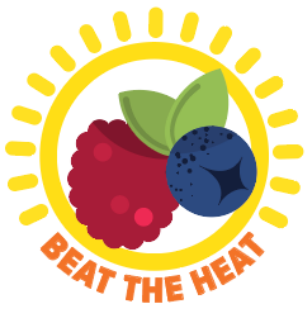


# Conclusions and Next Steps

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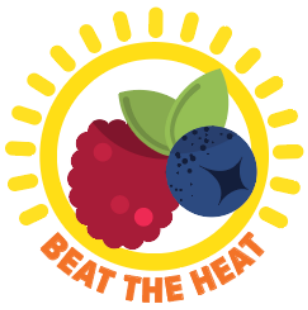
- Yield, photosynthetic, and stem water potential data demonstrate shade cloth and evaporative cooling mitigate heat stress with some genotype and genotype x treatment interactions for certain photosynthetic variables
- Evaporative cooling caused a noticeable increase in postharvest disease in the ORUS genotype
- Data collection will continue into 2025
- Cost benefit and adoption surveys are ongoing to inform adoption and outreach strategies



# Considerations



Shade cloth	Evaporative cooling
<b>Pros:</b>	<b>Pros:</b>
<ul style="list-style-type: none"> <li>• Dual function as hail netting</li> </ul>	<ul style="list-style-type: none"> <li>• Less expensive relative to shade cloth (\$10,380-\$11,864 USD per ha)</li> </ul>
<ul style="list-style-type: none"> <li>• Most effective at mitigating physiological indicators of heat and water stress</li> </ul>	<ul style="list-style-type: none"> <li>• Cools and provides some protection</li> </ul>
<ul style="list-style-type: none"> <li>• Reduces UV damage (sunburn)</li> </ul>	<ul style="list-style-type: none"> <li>• Chemigation</li> </ul>
<b>Cons:</b>	<b>Cons:</b>
<ul style="list-style-type: none"> <li>• Expensive to install (\$24,700-\$30,000 USD per hectare) and maintain</li> </ul>	<ul style="list-style-type: none"> <li>• Access to quality irrigation water may be limiting in some areas and in the future</li> </ul>
<ul style="list-style-type: none"> <li>• Wind events necessitate repairs (leading to higher maintenance costs)</li> </ul>	<ul style="list-style-type: none"> <li>• May increase fruit and storage rot, decreasing shelf life</li> </ul>
<ul style="list-style-type: none"> <li>• May interfere with machine harvest and other equipment operations</li> </ul>	<ul style="list-style-type: none"> <li>• Increased weed pressure</li> </ul>
<ul style="list-style-type: none"> <li>• May delay ripening and impact quality</li> </ul>	

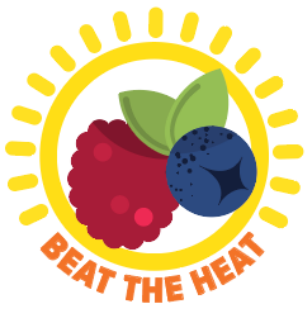


# Final Thoughts

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- Breeding for heat tolerance is an important, but long-term goal
- Need to develop short-, medium-, and long-term solutions across a range of farm scales, conditions, and economic scenarios
- Important to partner with industry to identify potential solutions and bridges and barriers to adoption



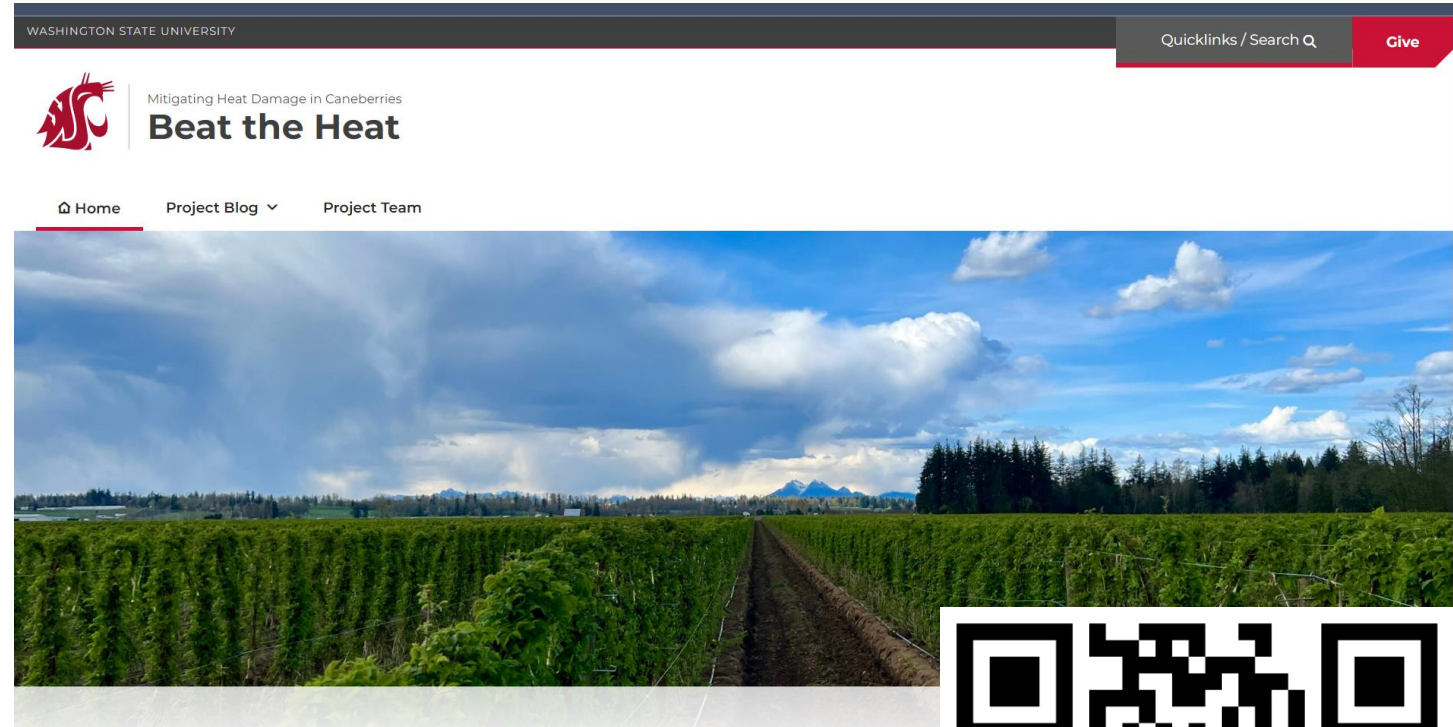


# Acknowledgements

- Tyler Westenber, Maggie McGlothorn, Scott Orr, and Per McCord
- Justin Ellgen @ Simplot

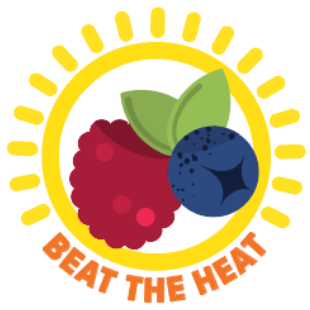


Funded by the USDA Specialty Crop Multi-State and WSDA Specialty Crop Block Grant Program (Agreement Number: K3888)



# Thank you! Questions?





# Coming Soon!

## How to Mitigate Heat Stress during Blueberry Pollination?

### BEAT THE HEAT:

PROTECTING BLUEBERRY POLLINATION DURING EXTREME HEAT EVENTS



Research Objectives:

#### Objective 1:

Determine the effects of evaporative cooling on flower temperature, honey bee activity, pollination outcomes, and fruit quality.

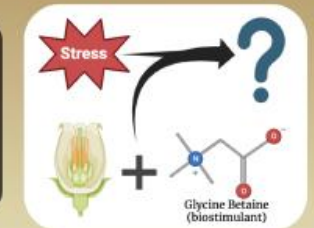


#### Objective 2:

Quantify the effects of different groundcover practices on canopy temperatures, along with associated risks of heat damage.

#### Objective 3:

Evaluate the impacts of biostimulants on pollen viability and pollination outcomes during extreme heat events.



#### Objective 4:

Calculate cost-benefit of listed heat mitigation technologies and extend information to industry.

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MSU



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