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

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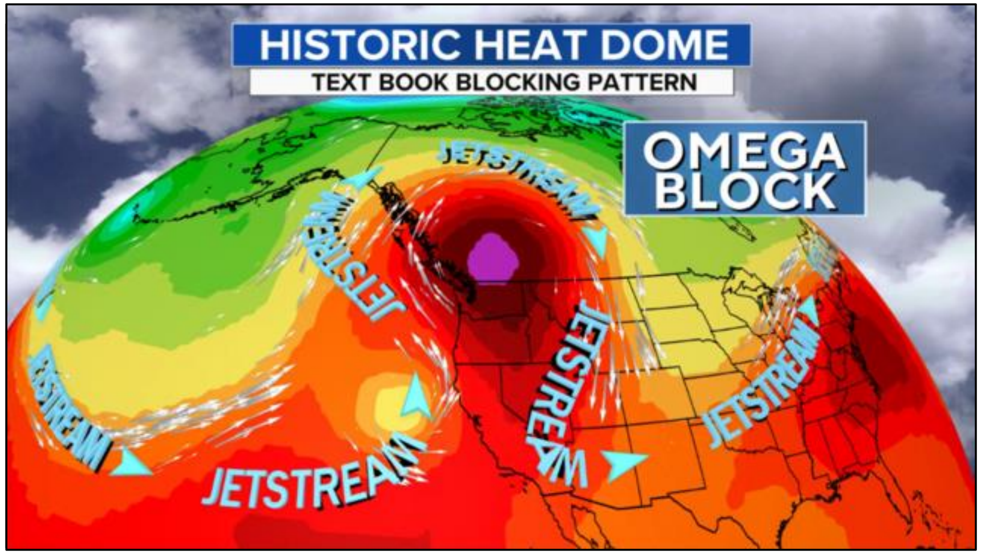
Pacific Northwest Raspberry

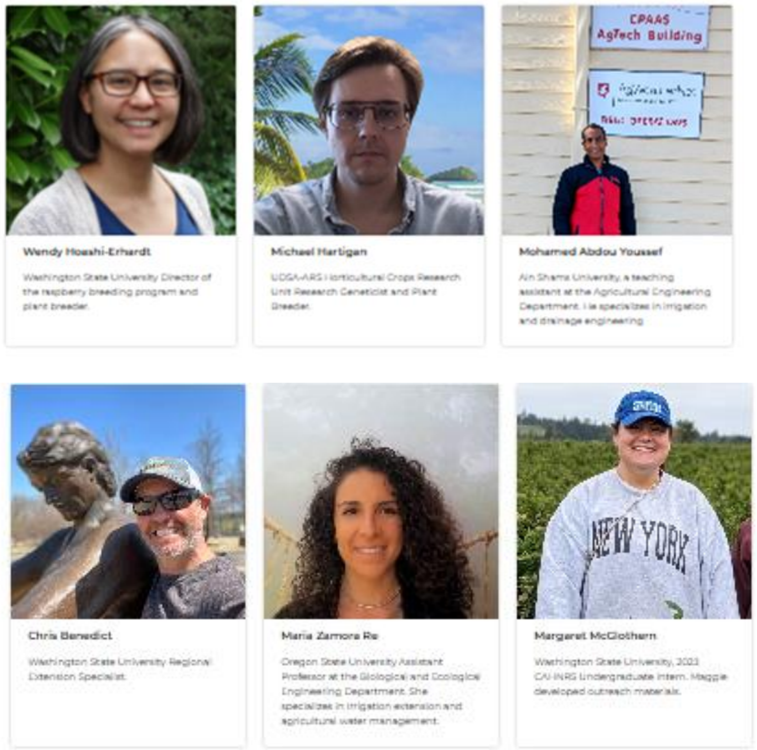
Mediterranean climate has historically been ideal for growing high quality fruits for fresh and processed markets

Heat Events are on the Rise



- 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



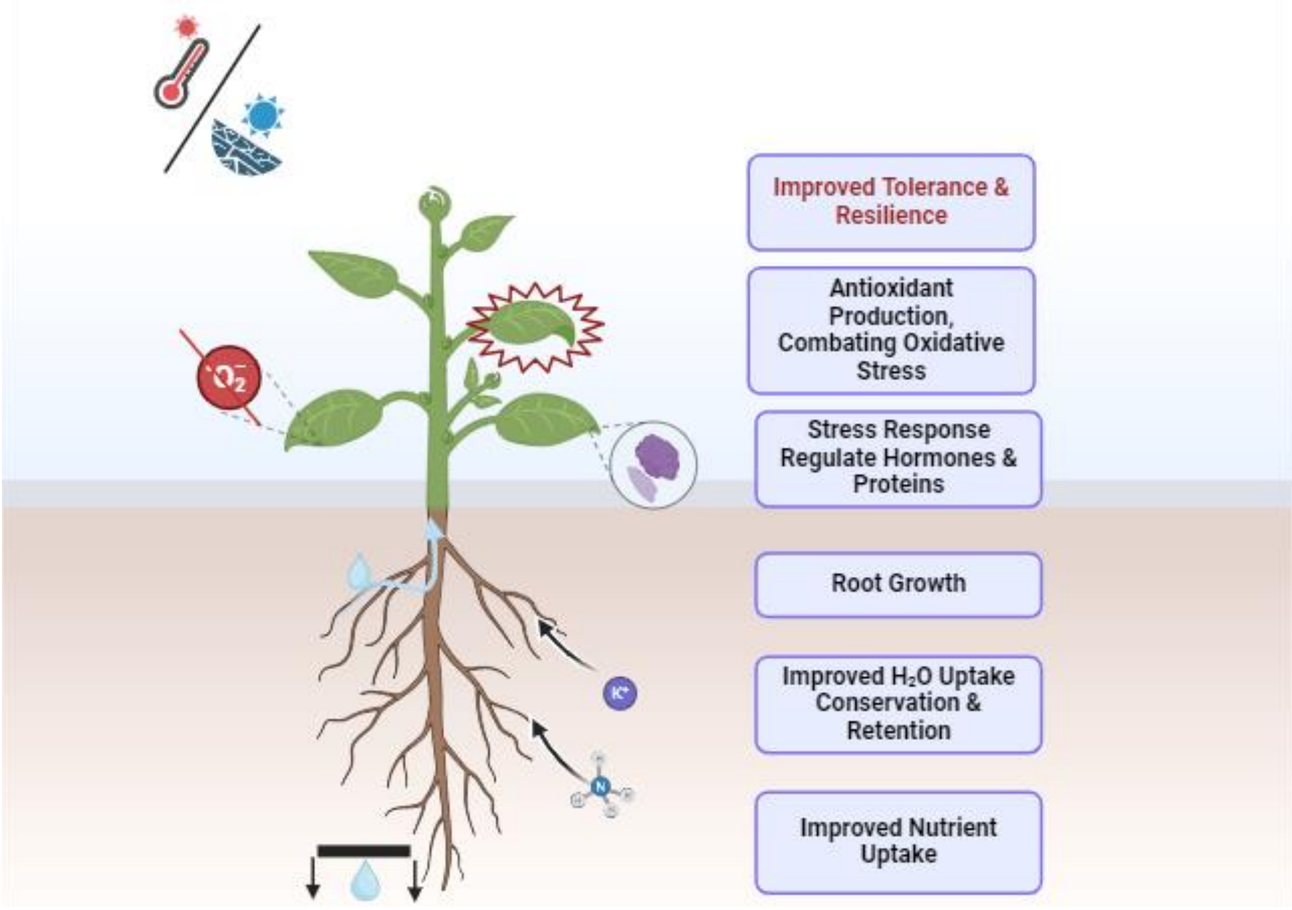
- Multi-institutional team of researchers, extension specialists, and students
- Expertise: horticulture, physiology, engineering, breeding, economics, extension

Project Objectives

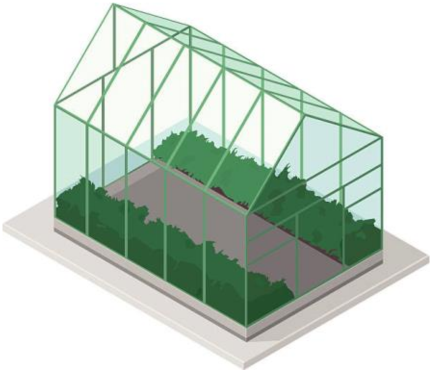
1. Evaluate the impacts and cost-benefits of heat mitigation technologies across several cultivars and promising selections of raspberry
   - *Heat protectants*
   - *Evaporative cooling and shade cloth*
2. Examine the physiological and genetic mechanisms that contribute to heat tolerance across cultivars 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



WSU IAREC
Prosser, WA
June - Sept ‘23

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

500g/pot

5g/pot

3g/pot

100% FC

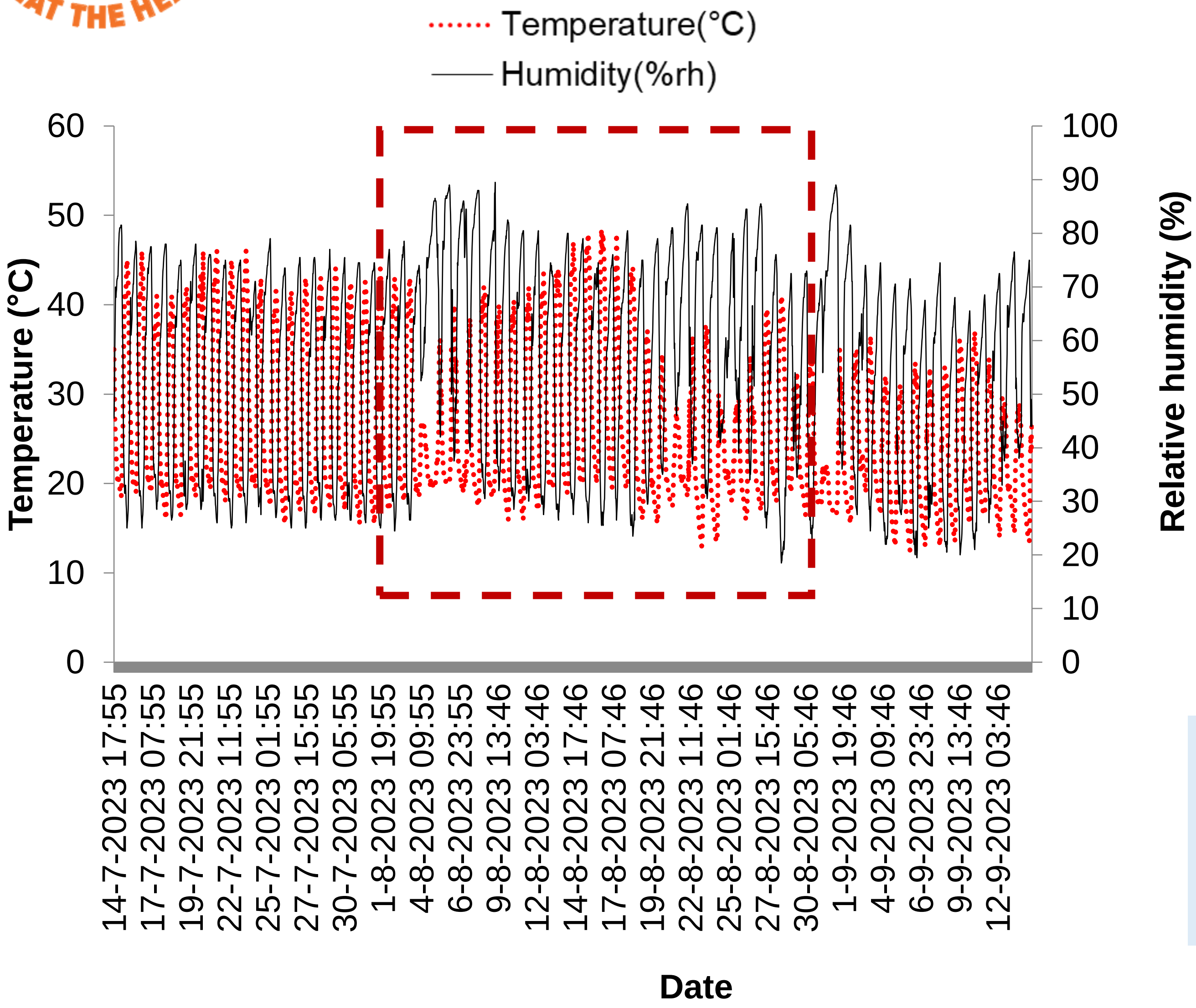
Experimental Design + Treatments

Treatments*	Application rate		Primary ingredients
	Foliar	Soil	
Control (untreated)	-	-	-
FRUIT ARMOR	1g L^{-1}	5.2 g L^{-1}	97% glycine betaine
Optysil	1 mL L^{-1}	2.5 mL L^{-1}	200 g SiO_2 and 24 g Fe in 1 dm^3
KelpXpress	1 mL L^{-1}	2.5 mL L^{-1}	Kelp (*Ascophyllum nodosum*) extract with protein hydrolysate, KH_2PO_4, 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_2O control)
- Applied weekly during experiment
- Weekly data collection on physiological variables and biomass

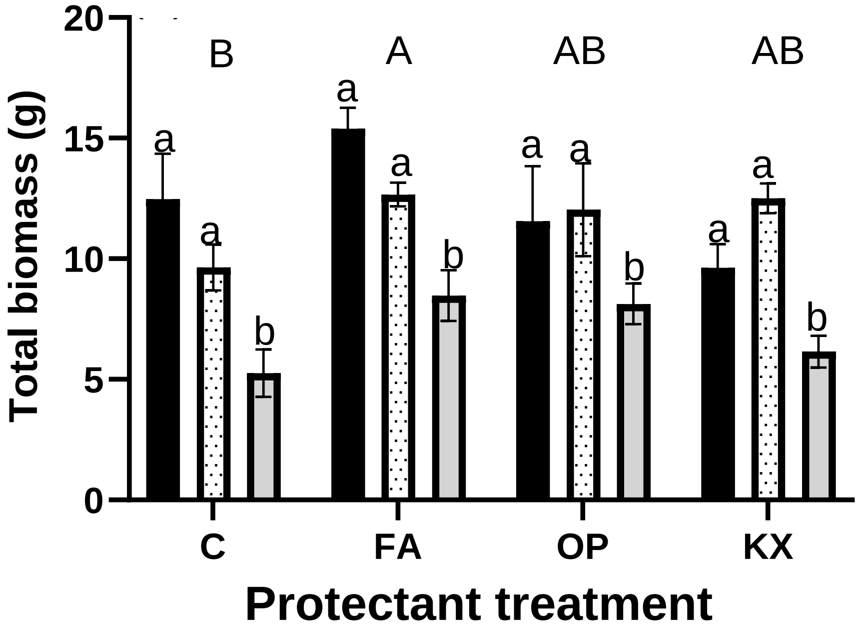
Glasshouse Conditions



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

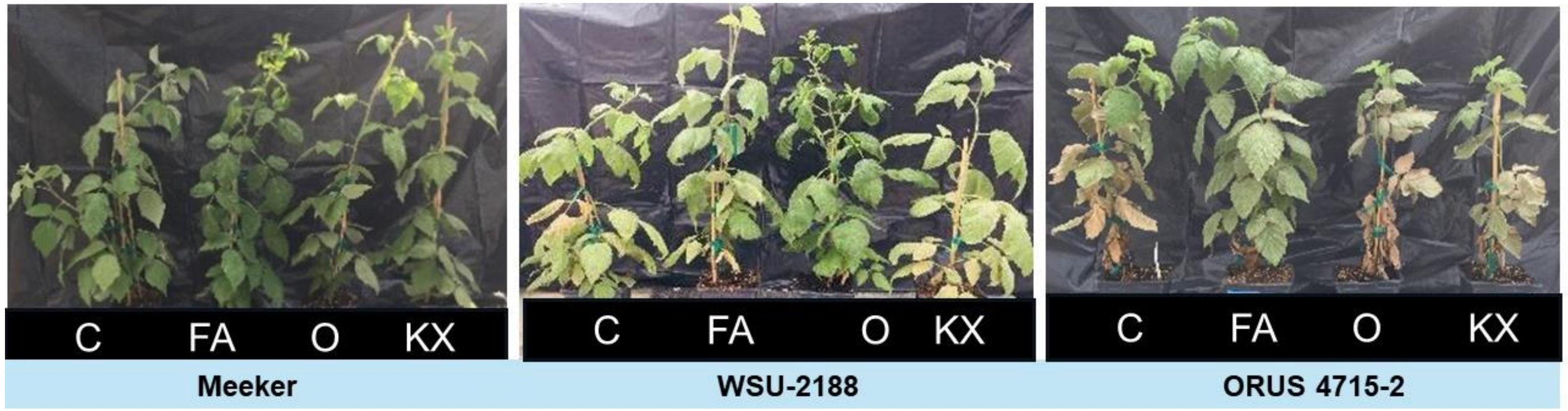
Makonya et al. (2025) *In press*

Biomass



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

Meeker
WSU 2188
ORUS 4715-2

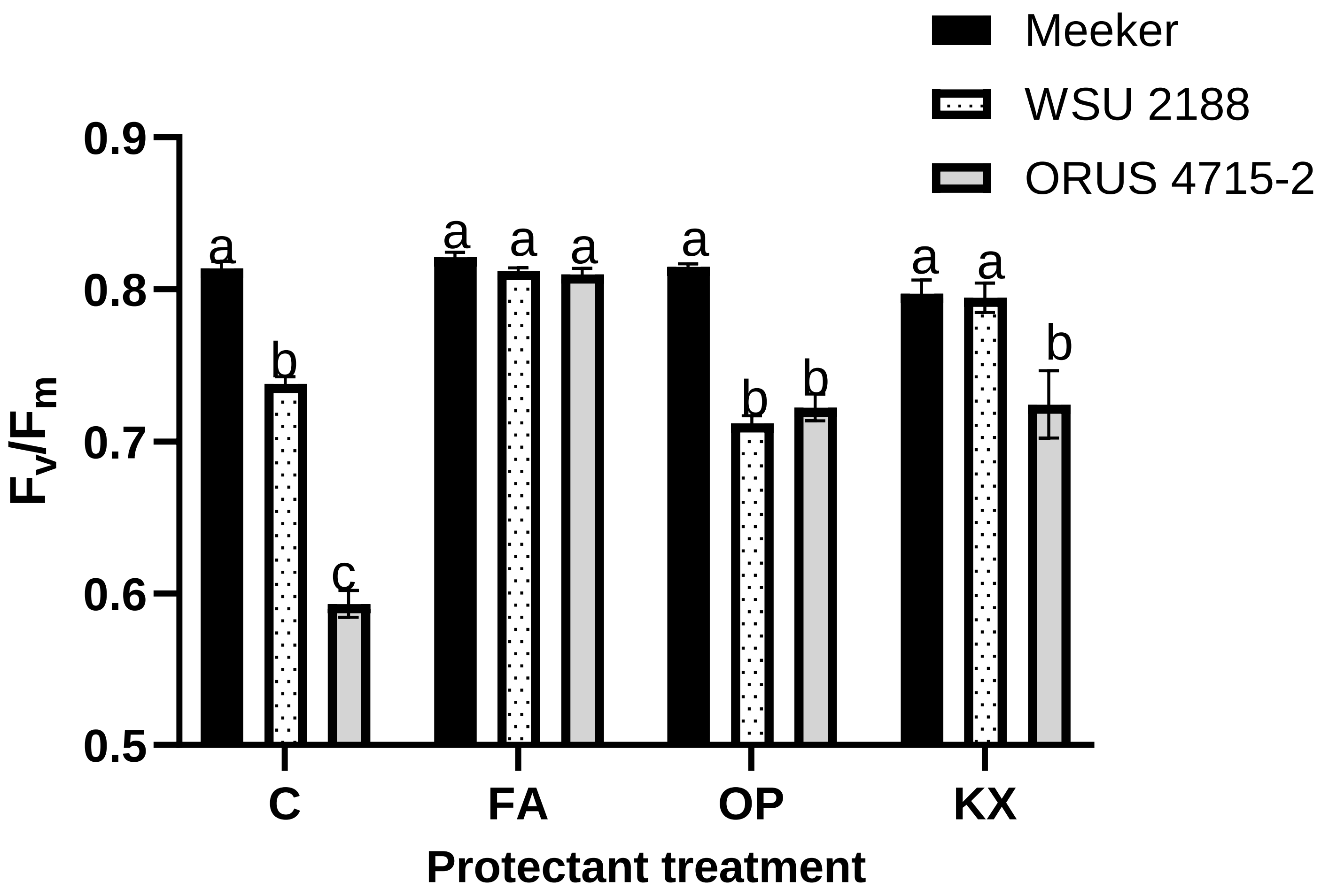


- Total biomass was greatest for ‘Meeker’ and WSU 2188
- Fruit Armor (FA, glycine betaine) increased biomass compared to the untreated control

Makonya et al. (2025) *In press*

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



Makonya et al. (2025) *In press*

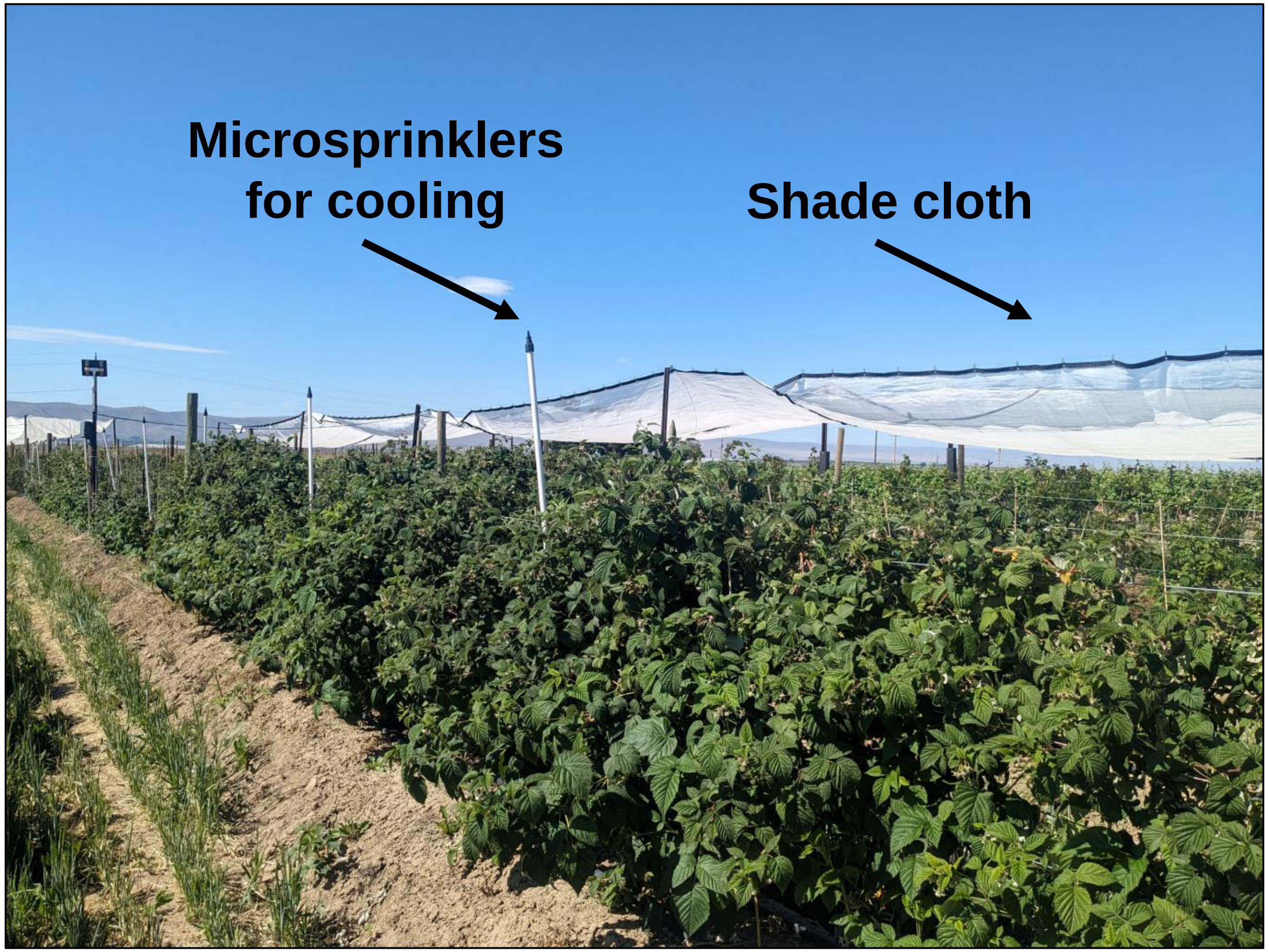
Conclusions and Next Steps

- ‘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 evacuating application rates, timing (growth stage), and methods of application

Makonya et al. (2025) *In press*

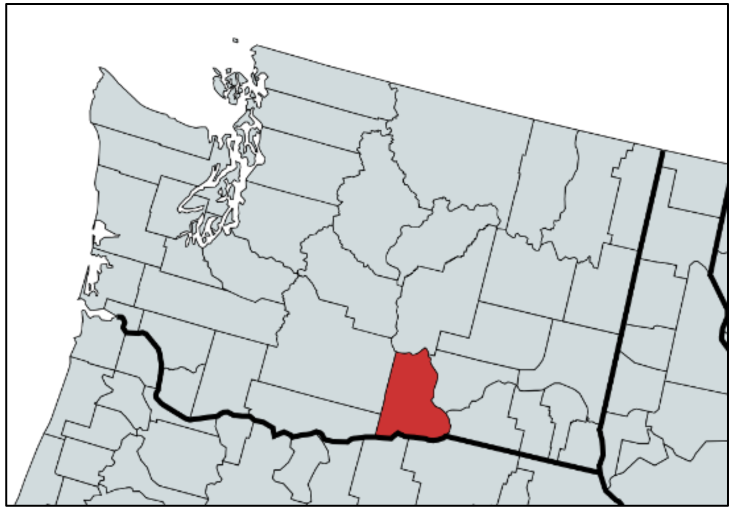
Heat Mitigation Using Evaporative Cooling and Shade Nets

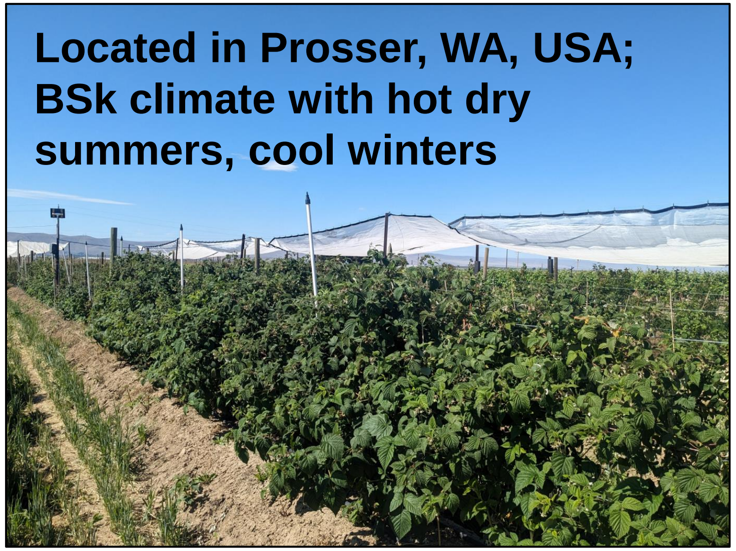
- Heat protectants are still an "unproven" technology
- Evaporative cooling and shade cloth are more established techniques to mitigate heat
- However, research on these technologies for raspberries is limited



Experimental Design + Treatments

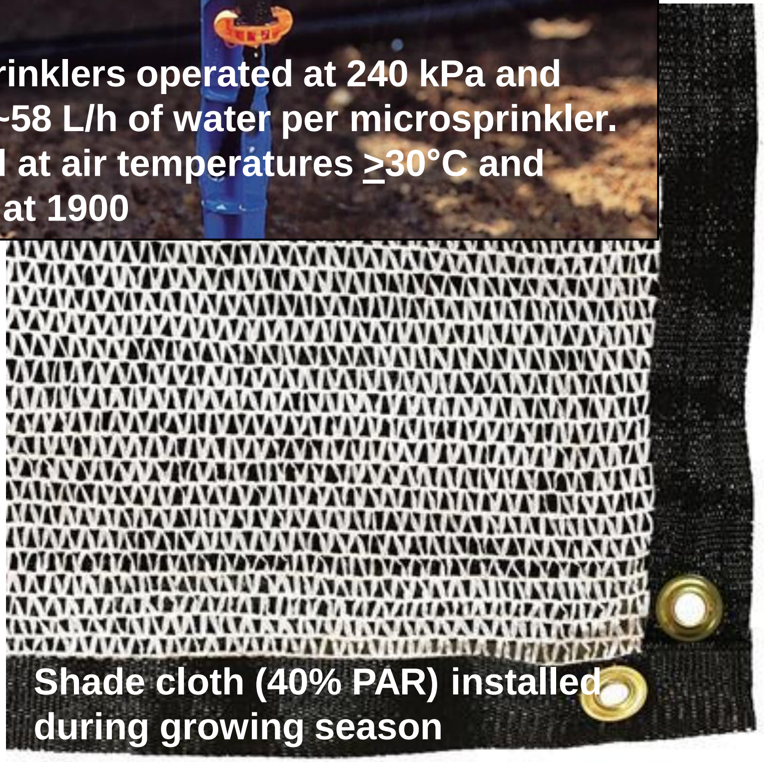
- Planted in Spring 2023
- Split-plot design
- 4 replications
- 11 plants per split plot
- Main plot (treatment):
  - Evaporative cooling
  - Shade cloth
  - Control (untreated)
- Split plot (genotype):
  - Meeker
  - WakeField
  - WSU 2188
  - ORUS 4715





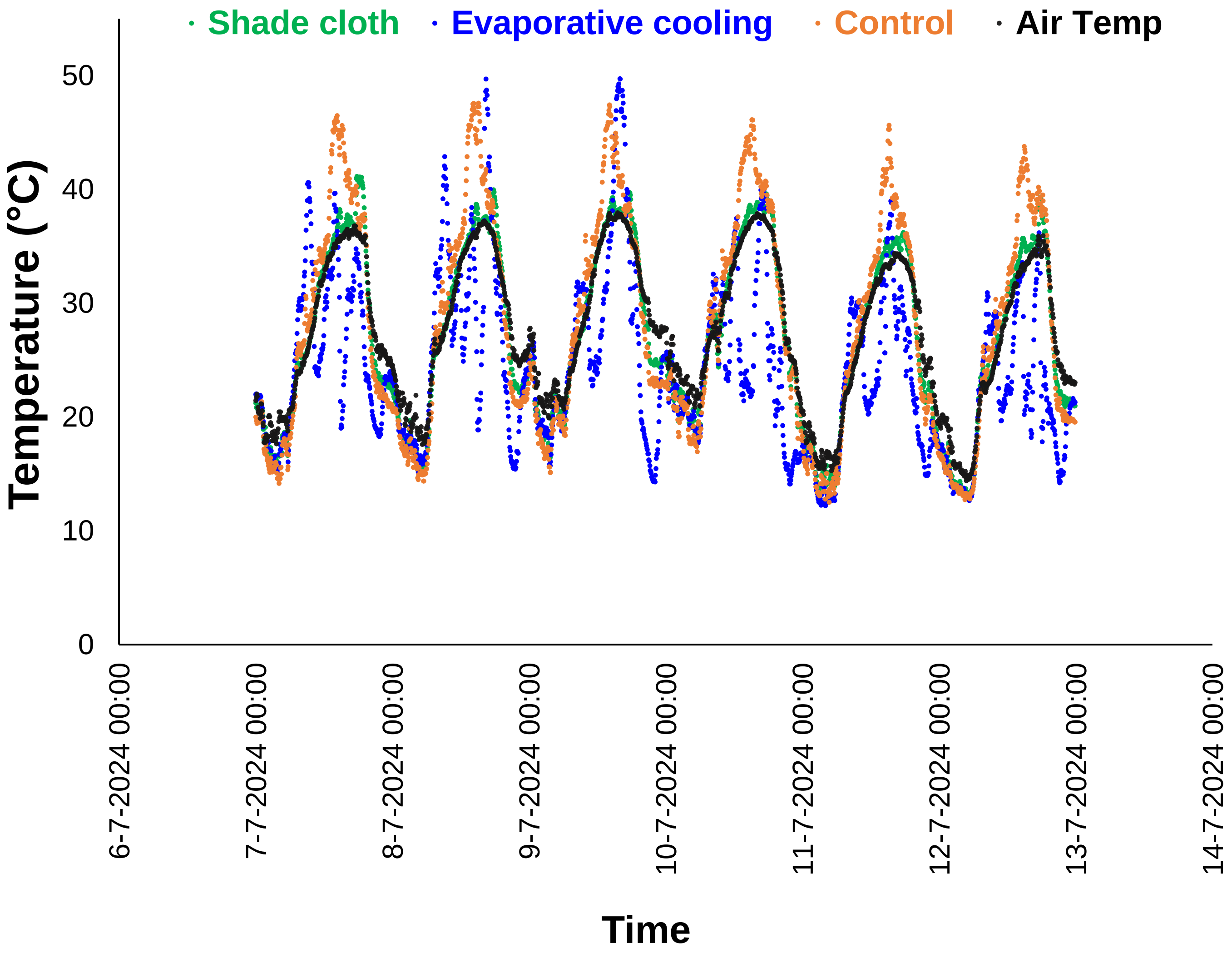
Located in Prosser, WA, USA; BSk climate with hot dry summers, cool winters

Microsprinklers operated at 240 kPa and applied ~58 L/h of water per microsprinkler. Actuated at air temperatures $\geq$30°C and stopped at 1900



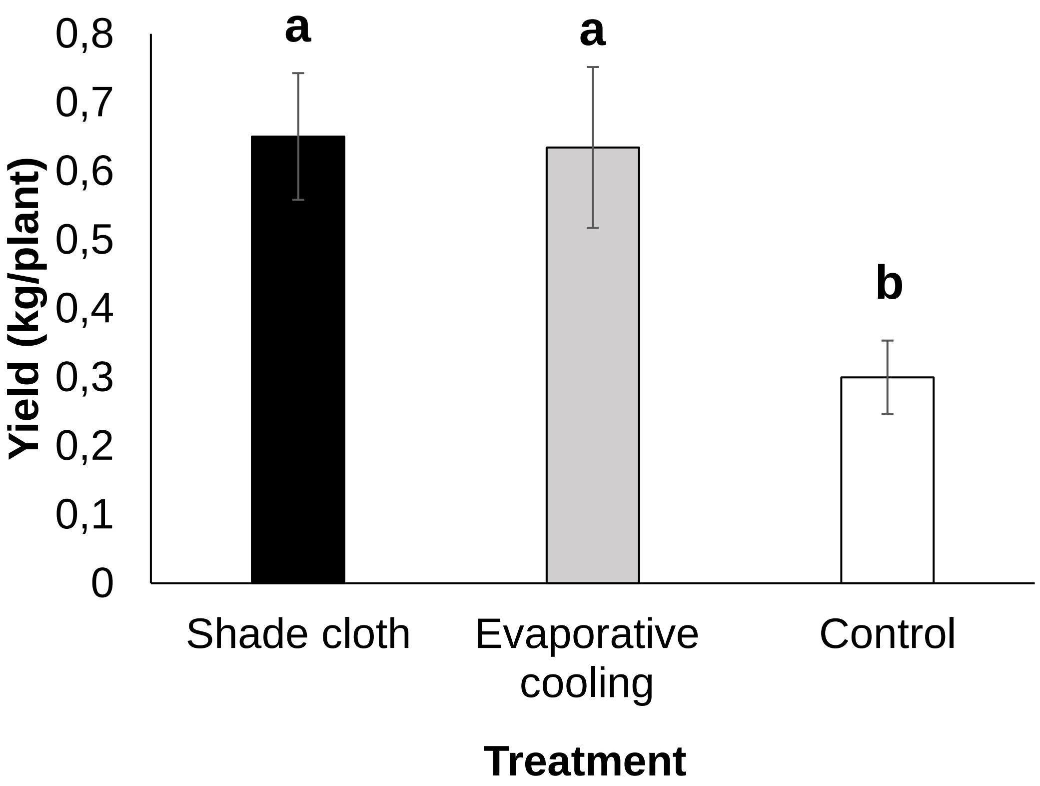
Shade cloth (40% PAR) installed during growing season

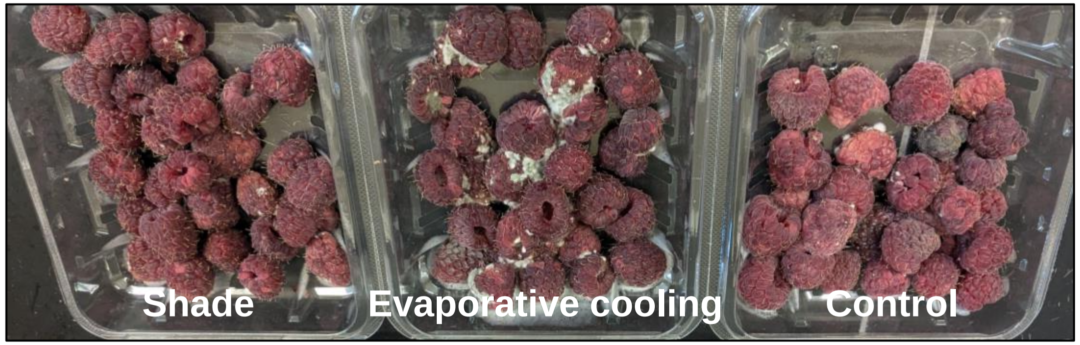
Fruit Surface and Air Temperatures



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[i]	-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

[i]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

- 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
Pros:	**Pros:**
• Dual function as hail netting	• Less expensive relative to shade cloth ($10,380-$11,864 USD per ha)
• Most effective at mitigating physiological indicators of heat and water stress	• Cools and provides some protection
• Reduces UV damage (sunburn)	• Chemigation
Cons:	**Cons:**
• Expensive to install ($24,700-$30,000 USD per hectare) and maintain	• Access to quality irrigation water may be limiting in some areas and in the future
• Wind events necessitate repairs (leading to higher maintenance costs)	• May increase fruit and storage rot, decreasing shelf life
• May interfere with machine harvest and other equipment operations	• Increased weed pressure
• May delay ripening and impact quality	

Final Thoughts

- 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

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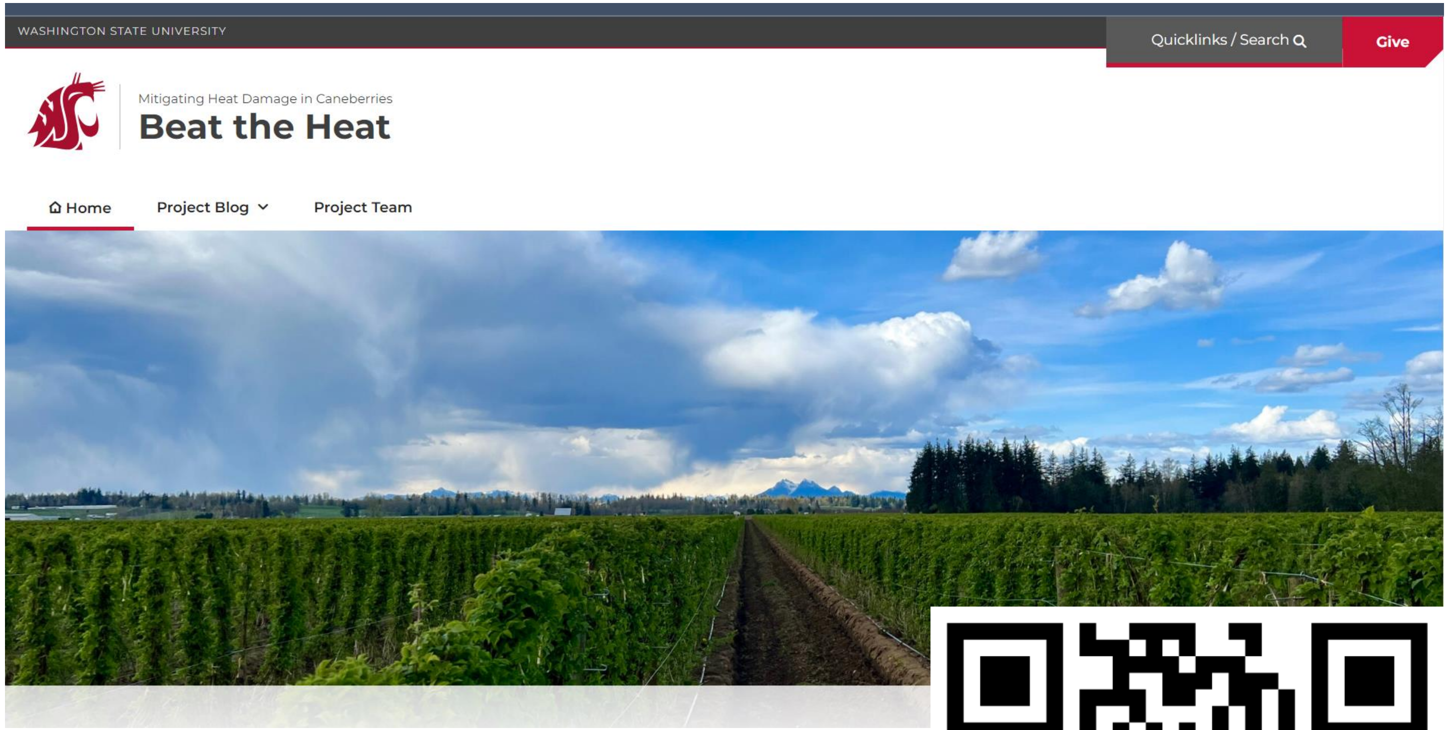
- Justin Ellgen @ Simplot



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Thank you! Questions?

Coming Soon!

How to Mitigate Heat Stress during Blueberry Pollination?