BEAT THE HEAT

Photo by Lisa Wasko DeVetter

Photo by Lisa Wasko DeVetter

Heat Mitigation in Raspberries and Blackberries in the Pacific Northwest

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Overview

This guide describes heat stress, its negative impact on caneberries (*Rubus* spp.; raspberry and blackberry), and reviews strategies to reduce heat stress for caneberry growers in the Pacific Northwest. Standard heat mitigation approaches are emphasized, including shade cloth and overhead cooling, along with costs and benefits information through partial budget analysis. The potential role of biostimulants and other horticultural practices in mitigating heat stress are also described.

What is Heat Stress?

Heat stress is a physiological condition that occurs when air temperatures exceed the optimal range for plant functioning. It has become an increasingly significant threat to the health and productivity of caneberries in the Pacific Northwest and other major caneberry-producing regions worldwide. Heat stress typically arises during heat waves—climatic events characterized by prolonged periods of excessively high air temperatures (World Health Organization, 2025). These events often coincide with additional stressors such as low humidity, intense solar radiation, and drought, which compound plant stress and further reduce yield and fruit quality.

When plants experience heat stress, their ability to cool themselves through transpirational cooling becomes impaired (Figure 1). Transpirational cooling occurs as plants release water vapor through tiny pores on their leaves, called stomata, which cools leaf surfaces via evaporation. Under high temperatures and limited water availability, stomata often close to conserve moisture. This closure also restricts carbon dioxide uptake required for photosynthesis, weakening plants, reducing yields, and diminishing fruit quality by limiting sugar production. Additionally, closed stomata inhibit transpirational cooling, causing canopy temperatures to rise even further.

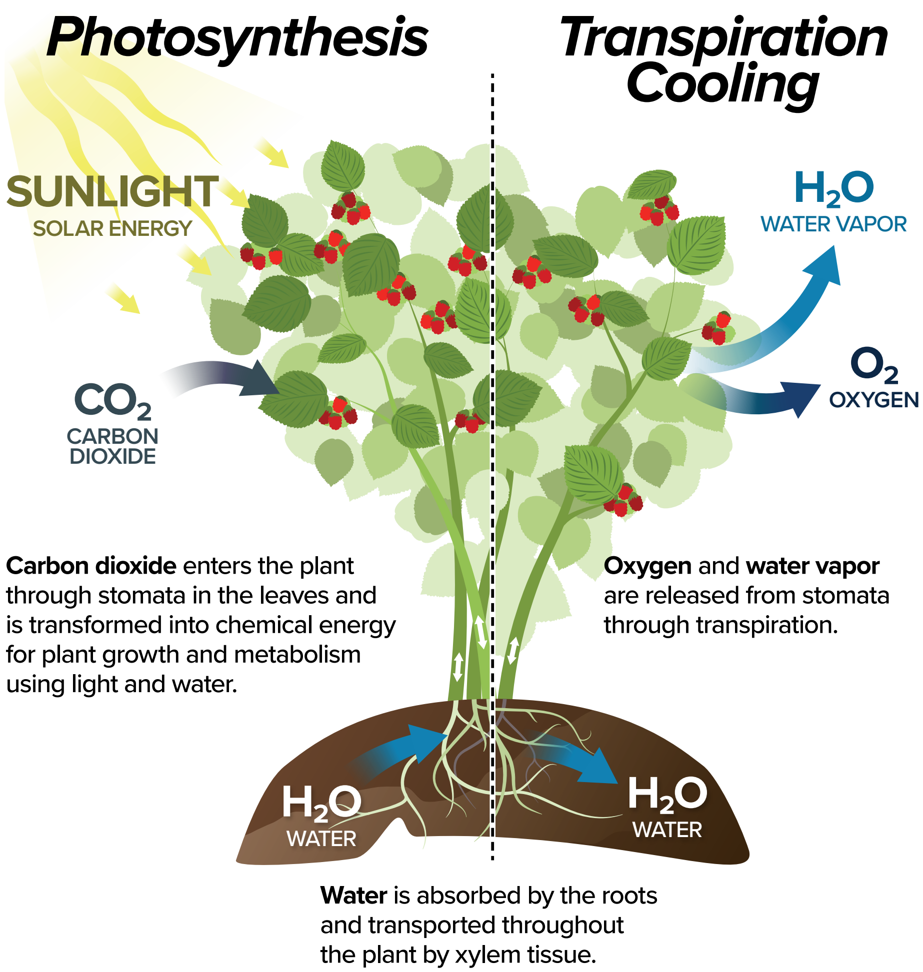

Figure 1. Illustration of photosynthesis and transpirational cooling. Image by Andrew Mack.

Visual symptoms of heat stress includes leaf wilting, curling or scorched leaves, and shriveled or sunscalded (i.e., “bleached”) fruit (Figure 2). The critical temperature at or above which heat damage may occur depends on sunlight intensity, humidity, and plant water status. The thermal mass of fruit also influences critical temperatures for the fruit and is related to the capacity of fruit to absorb, store, and release heat. The critical temperature at or above which heat damage may occur in raspberry or blackberry fruits has not been definitively established. However, preliminary studies show that elevated temperatures ≥90°F inhibit plant growth, fruit yield, and quality.

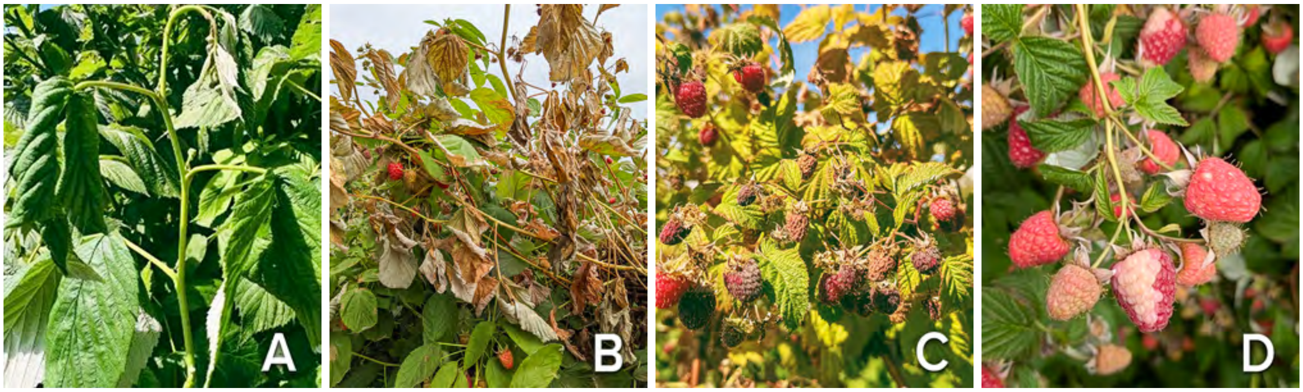

Figure 2. Visual symptoms of heat stress include (A) leaf wilting and curling or (B) scorched leaves, and (C) shriveled or (D) sun scalded fruit. Photos A-C by Ashley Fincham; photo D by Lisa W. DeVetter.

Understanding the risk of heat stress for your local environment, recognizing conditions that lead to heat stress, and identifying heat stress symptoms are crucial to implementing an effective heat mitigation strategy. Research has shown that techniques such as shade cloth and overhead cooling using microsprinklers can significantly reduce heat stress, leading to improved plant growth, yield, and fruit quality. These methods create better conditions for photosynthesis and plant growth. Other approaches, such as the utilization of effective biostimulants and good horticultural practices, may also reduce the negative effects of heat stress. This guide reviews these approaches to help growers and crop advisors identify and implement the most effective strategies for the specific conditions of their operations.

Shade Cloth for Heat Protection

Shade cloth is a material suspended above plants that provides partial shade and protection to plants from solar radiation and associated heat produced by sunlight (Figure 3). By filtering solar radiation and reducing its intensity, shade cloth prevents or reduces sunburn, leaf scorch, wilting, and sunscald, all of which are common symptoms of heat damage. Shade cloth can also provide protection from other environmental hazards, such as wind and hail. Additionally, shade cloth can reduce water loss from the soil through evaporation and contribute to better plant hydration.

Figure 3. Shade cloth suspended above plants used to provide partial shade and protection to plants from solar radiation and associated heat produced by sunlight. Photo by Ashley Fincham.

Collaborative research led by Washington State University has shown that using shade cloth can provide a more favorable growing environment for raspberry grown under high temperature conditions, which leads to increased raspberry yields when compared to no shade cloth. Fruit surface temperatures of shaded fruits were also reduced by approximately 9°F compared to non-shaded fruits. Initial findings suggest that 40% shade cloth coverage provides significant benefits to caneberries in the Pacific Northwest.

Shade cloth percent refers to the percentage of incoming light blocked. For example: 40% shade cloth transmits approximately 60% of photosynthetically active radiation (PAR), the light spectrum plants use for photosynthesis. In contrast, 60% shade cloth transmits approximately 40% of PAR. While 40% shade cloth (transmitting about 60% PAR) has been effective at reducing the negative effects of heat in raspberry, a range of 30-70% shade coverage has been recommended depending on local conditions that influence the intensity of heat and solar radiation (Liu & Shahid, 2023).

The color of shade cloth can influence plant response to heat and affect development, growth, and stress mitigation. White and black shade cloth are common, while other colors have been studied in crops like table grapes (*Vitis vinifera*), apples (*Malus* × *domestica*), and blueberries (*Vaccinium corymbosum*) (Stamps, 2009). In blueberries, black shade cloth cooled air temperatures more effectively during daytime hours until late afternoon, while white shade cloth retained more heat in the morning but decreased air temperatures during the late afternoon (Zoratti et al., 2015). White shade cloth also tended to ripen blueberry fruits more evenly and quickly while reducing humidity by 10%. Ultimately, the color choice of shade cloth will depend on a producers' goals and specific climate conditions.

When installing shade cloth, it is crucial to select a support structure sturdy enough to withstand wind, rain, and hail while keeping the cloth taut to avoid sagging and water pooling. Conduct routine checks of the shade cloth for signs of debris accumulation, wear, tear, or damage, especially after storms or high winds. Early detection of small rips can allow for repairs using fabric adhesives or patches. Because shade cloth can reduce airflow and increase humidity, there may be a higher risk of fungal diseases, making partial or removable coverage a practical option to reduce disease incidence.

Retractable systems, such as motorized or manual pulley systems, are especially beneficial, as they improve ventilation and maintain insect pollinator access during bloom periods. Shade cloth should be removed after peak heat stress conditions to avoid interfering with fruit bud development for the following season. If the system allows for retraction from the center, this can be a viable alternative to full removal, helping avoid potential damage. For traditional shade cloth systems, remove the cloth and store it in a dry location during the winter months in areas that experience snowfall, as accumulated snow can cause the shade cloth and support structure to break. Additionally, because the cloth intercepts rain and reduces evaporation, growers need to adjust irrigation plans accordingly to maintain optimal soil moisture levels.

Drawbacks of shade cloth include high installation costs, ongoing maintenance requirements (particularly in areas prone to wind damage), and potential interference with machine harvesting and other mechanical operations (see the "Costs and Benefits" section on page 6). Shade cloth may also delay fruit ripening and impact fruit quality. Growers interested in shade cloth are advised to test it in a small block on their farm before scaling up and monitor for changes in disease and pest pressure, as well as fruit ripening and quality.

In addition to manufactured shade cloth, small farms can consider using natural shade options, such as planting caneberries in areas that receive afternoon shade from nearby buildings, fences, or hedgerows. These shading strategies can reduce heat exposure during the hottest part of the day, helping to buffer crops against heat extremes.

Overhead Cooling with Microsprinklers

Overhead or "evaporative" cooling systems are another effective heat mitigation technique. Overhead microsprinklers apply water to the plant canopy to increase evaporative cooling and also facilitate some cooling through convection and conduction (Figure 4). Research conducted by Washington State University showed that continuous overhead cooling using microsprinklers can lower raspberry fruit surface temperatures by up to 20°F compared to non-cooled fruit. This method is effective in areas where water is available and temperatures are high.

Overhead cooling systems can be run continuously during periods of high heat until air temperatures are below critical temperature thresholds. However, continuous cooling can be problematic if water availability is limited. Continuous cooling can also worsen problems with weeds, slugs, fruit rot, and excess soil moisture in the rootzone. Running sprinklers in cycles throughout a heat event is a good alternative to continuous cooling and can be particularly useful for conserving water and limiting problems due to excess moisture in the field. Research led by USDA-ARS has shown cycling overhead cooling cycles using microsprinklers (e.g., 20 minutes on and 40 minutes off) is effective in blueberry and can reduce water use by up to 50% compared to continuous cooling (Yang et al., 2020).

Other temperature-based approaches to inform overhead cooling strategies are also being explored. A promising approach is temperature-actuated cooling, in which overhead cooling is triggered when critical air or canopy temperature thresholds measured from field-based sensors are reached. Once temperatures fall below the threshold, cooling is programmed to then cease. For example, overhead cooling in a raspberry field is triggered when air temperatures rise above 90°F and automatically shuts off when the temperature drops below 84°F. Findings to date show this approach reduces water use by 74% compared to continuous cooling in raspberry fields. This strategy requires temperature sensors and loggers, which are becoming increasingly adopted by growers. Furthermore, advances in Long Range Wide Area Network (LoRaWAN) enhance the ability for growers to remotely monitor their fields.

Figure 4. Micro-sprinkler used for overhead cooling of the plant canopy. Photo by Ashley Fincham.

When considering overhead cooling, the most critical factors are water source, quality, and availability. Overhead cooling systems depend on a steady water supply. In regions where water is scarce, such as parts of the Pacific Northwest, this constraint shapes every aspect of design and operation. If water is limited, options like fogging may be more viable (see the "Fogging Systems" section on page 5). Assess whether your water source has high iron content or is considered "hard" (high in dissolved minerals). Water testing is best conducted in the summer months when irrigation demand is highest and conditions reflect actual use scenarios. The accuracy of lab results is influenced by how and when water is sampled, so proper collection methods are critical. High iron and hardness can cause significant clogging issues in emitters and filtration systems. High iron levels, in particular, may require infrastructure such as a pond with at least a three-day holding capacity to allow iron to oxidize and settle out. Water from the upper layers can then be filtered, treated, and used in the system. However, this setup requires adequate acreage and may necessitate larger ponds than those used for traditional drip irrigation, potentially making overhead cooling cost-prohibitive for some operations. Be sure to consult with a local irrigation specialist regarding water quality, water availability, and system design before implementation.

Beyond water, growers must evaluate soil type, climate, crop or cultivar sensitivity to heat, infrastructure compatibility, labor availability, budget, and return on investment. A comprehensive soil map is important for tracking water-holding capacity and drainage differences across a field. A single 80-acre plot might contain several distinct soil types, each requiring a different approach to irrigation and cooling. Because of this variability, each system must be custom-designed; there is no one-size-fits-all solution. Professional irrigation designers are key partners in this process. Today's designs require expertise in pressure regulation, emitter spacing, pump sizing, hardware selection, and climate considerations. Mistakes in design can undermine crop quality, waste water, and even risk total crop loss. Many funding programs, such as the USDA's EQIP initiative, now require professional design to ensure systems are efficient, sustainable, and tailored to site-specific conditions.

Microsprinkler emitter spacing and system layout must also reflect environmental factors. Uniform water distribution has long been a priority, often measured using Christiansen's uniformity coefficient. Because environmental conditions such as wind patterns and topography vary greatly, designing systems tailored to the unique microclimate and crop layout is far more effective than simply pursuing uniform emitter spacing.

Building on emitter placement, effective system operation utilizes cycling strategies that balance water conservation with cooling needs. These strategies help conserve water while maintaining cooling efficiency. Systems are operated throughout the hottest parts of the day, typically for up to eight hours, and are paused at night, during very windy conditions, or when humidity rises. These decisions rely on growers' site-specific observations and technology. System controls range from manual, simple timers to more advanced automation.

To further control water distribution, shields can be used to prevent spray from hitting crops, walkways, or roads. While shields are not universally used in overhead cooling systems, they are essential in frost protection to keep spray off roadways and pathways to ensure safety. Although it is technically possible to adapt an overhead microsprinkler system for freeze protection by increasing water application rates, this practice is uncommon and generally not recommended.

Maintenance of overhead cooling systems is straightforward but essential. At the end of the season, systems are winterized by either draining or blowing out lines to prevent damage from freezing. Flush valves are installed at line ends to prevent clogging, and filters must be properly sized (usually one-third the nozzle diameter) to protect against debris. In some operations, chlorine is injected to sanitize lines, particularly in berry crops, where food safety is of paramount importance.

Ultimately, the success of any cooling system lies in balancing environmental variables, water limitations, and crop-specific needs. Irrigation specialists can design systems that consider these dynamic factors while supporting fruit quality, resource conservation, and long-term viability.

Overhead cooling is generally less expensive than shade cloth and offers additional benefits for growers, such as potential use for chemigation, compatibility with machine harvest, and increased yields. However, it may have limited application in western regions where humidity is high and proper design and installation requires working with a specialist. Refer to the "Costs and Benefits" section on page 6 for additional information.

Fogging Systems

Fogging systems work similarly to overhead cooling, producing very fine droplets that cool the surrounding air with minimal wetting of leaves or fruit. Choosing between overhead microsprinklers or fogging systems must be done carefully. Traditional high-pressure fogging systems (90 psi) have largely been replaced by low-pressure alternatives (15–30 psi), which reduce mechanical stress and improve reliability. While fogging is preferred in dry, low-humidity environments due to rapid evaporation, it becomes less effective in humid conditions, particularly when relative humidity exceeds 60%. Further research is needed to precisely determine the relative humidity threshold at which fogging efficacy significantly declines. Fogging systems also are less effective in windy environments, which is why their use is primarily limited to greenhouses or other protected structures. Fogging systems are especially unsuitable for frost protection, as their fine droplets freeze before leaving the nozzles. Additionally, high water pressure and water quality are necessary to avoid clogging when using fogging systems. At this time, fogging systems are not recommended for commercial caneberry production systems in open fields in the Pacific Northwest, but future research may support their use.

Biostimulants

Biostimulants are commercial products made from naturally occurring substances and/or microorganisms that may help plants tolerate environmental stressors like heat and drought. They are designed to be applied in small amounts, as foliar and/or soil applications, without supplying nutrients directly. These formulations often include ingredients such as humic substances, beneficial chemical elements, chitin and chitosan derivatives, seaweed or plant extracts, inorganic salts, anti-transpirants (e.g., kaolin and polyacrylamide), plant growth-promoting microorganisms, and free amino acids and nitrogen-containing substances.

Studies with biostimulants have shown encouraging results, with some evidence suggesting that biostimulants may enhance heat tolerance and help maintain plant performance under stress. For example, glycine betaine and kelp extract [from brown seaweed (*Ascophyllum nodosum*)] improved juvenile raspberry plant tolerance to heat stress relative to untreated plants in a glasshouse experiment where temperatures reached 95°F for several days (Makonya et al., 2025). The positive effects observed in emerging research suggest that certain biostimulants support the maintenance of photosynthesis, hydration status, and the plant's capacity to naturally cool through transpirational cooling, ultimately contributing to improved plant growth and performance under heat stress.

It is important to recognize that the effectiveness of commercial biostimulants remains under evaluation. More research is needed, especially in fruit crops, to understand the optimal timing of applications, recommended application frequency, variability in effectiveness among biostimulant types, cost effectiveness, and how reliable these products are across different cultivars, crop types, and heat events. However, they may eventually offer an effective tool for heat mitigation and climate resilience.

Costs and Benefits

Any technology has pros and cons that must be carefully considered before implementation on a farm. A general list of pros and cons for shade cloth, overhead cooling, and biostimulants is found in Table 1.

Table 1. A summary of the pros and cons of shade cloth, overhead cooling, and biostimulants for heat mitigation in open-field caneberry systems in the Pacific Northwest.

Cooling Technique	Pro	Con
Shade Cloth	+ Dual function as hail netting. + Most effective at mitigating physiological indicators of heat and water stress. + Reduces UV damage (sunburn).	− Expensive to install and maintain ($9,880-$12,000 USD per acre). − Wind events necessitate repairs (leading to higher maintenance costs). − May interfere with machine harvest and other equipment operations. − May delay ripening and impact quality.
Overhead Cooling	+ Less expensive relative to shade cloth ($4,152-$4,745 USD per acre). + Cools and provides some protection. + Chemigation.	− Access to quality irrigation water may be limited in some areas, and in the future. − May increase fruit and storage rot, decreasing shelf life. − Increased weed pressure.
Biostimulant	+ Can be rapidly applied in anticipation of an approaching heatwave. + Provides versatility in application methods, including foliar spraying and fertigation. + Does not interfere with machine harvest and other equipment operations	− Unpredictable costs due to multple applications and labor. − Optimal application timing is unclear. − Lack of data on effectiveness across biostimulant classes and extreme weather conditions. − Mode of action not always well understood, which may affect regulatory or buyer acceptance.

Table 2. Assumptions and data used in the partial budget analysis comparing overhead cooling, shade cloth, and a control of no heat mitigation for 'Meeker' floricane-fruiting raspberry in the Pacific Northwest.

Data	Value	Notes
Marketable yield (lb/acre): Control*	2,282	No mitigation, under extreme heat event; Marketable yield = Net of yield loss due to sunscald, shrivel and mold.
Crop yield gain with respect to Control, under extreme heat event (% of marketable yield)*	77%	With shade cloth
	33%	With overhead cooling
Manual weeding (hour/acre)**	2.5	Control
Percentage difference in manual weeding hours with respect to Control (%)**	-34%	With shade cloth
	42%	With overhead cooling
Market price ($/lb)**	2.40	Average packed price (price at the packinghouse door)
Labor cost ($/hour)	$19.82	Manual labor rate based on 2025 Adverse effect wage rate
	$20.82	More skilled or agricultural machinery/equipment workers
Irrigation system cost - materials + installation ($/acre)	$2,780	Baseline, single drip line; Material and installation cost for single drip line, automated
	$5,660	Overhead cooling: Material and installation cost for double drip lines and a sprinkler system for overhead cooling, with two separate sub-main lines; automated
Irrigation labor (hour/acre)	0.5	Baseline irrigation labor**
	9	Based on field studies (operation of Overhead Cooling is 18× more than Control)
Shade cloth, investment cost ($/acre)	$10,000	Material and installation cost
Operation of shade cloth ($/acre)	$600	Labor cost for deployment and retraction

Sources:
*Data for 'Meeker' from 2025 field studies; **2025 Red raspberry enterprise budget; Adverse effect wage rate (*https://flag.dol.gov/wage-data/adverse-effect-wage-rates*)

Notes:
Weeding hours: We used the weeding hours from the field studies, averaged across genotypes (Control = 134 min; Shade Cloth = 89 min; and Overhead Cooling = 190 min). Therefore, labor hours under the heat mitigation scenarios are 34% lower than Control for Shade Cloth, and 42% higher than Control for Overhead Cooling.

Irrigation labor: From the field studies, irrigation in Control = 15-20 minutes done once at the start of the growing season; in Overhead Cooling = approximately 15 minutes done twice a week for 12 weeks (i.e., 6 hours total for growing season). Based on 20 minutes (~0.33 hr) of irrigation in Control, irrigation labor in Overhead Cooling is 18 hours more than Control (i.e., 6 hrs divided by 0.33 hr).

A more detailed partial budget analysis is also presented in this section that leverages field trial data from Washington. The partial budget analysis estimates the economic implications of adopting heat mitigation strategies in red raspberry production under potential extreme heat events. The analysis compares a baseline scenario of no heat stress mitigation with alternative strategies to assess their costs and benefits. The assumptions used for the analysis are presented in Table 2 and summarized below.

- ***Baseline scenario:*** Represented by a 'no mitigation' control under extreme heat.
- ***Alternative scenarios:*** Two mitigation scenarios were examined in the event of an extreme heat episode: shade cloth and overhead cooling. Biostimulants were excluded due to lack of available data.
- ***Yield impacts:*** Yield data came from an established, experimental raspberry field in Prosser, Washington. Harvest data are from 2025 and reflect extreme heat conditions, with a cumulative 190 hours above 86 °F in July and 100 hours above 86°F in August 2025.
- ***Marketable yield:*** Yield levels used in the partial budgets are net of yield losses due to heat damage, shrivel, and mold. With respect to the 'no mitigation' control, marketable yields under shade cloth and overhead cooling are 77% and 33% higher, respectively.
- ***Weed management:*** Manual weeding requires 2.5 hours per acre under the baseline scenario, decreasing by 34% with shade cloth and increasing by 42% with overhead cooling.
- ***Irrigation system cost:*** Single drip irrigation system costs $2,780 per acre for the baseline scenario. Double drip lines and a microsprinkler system for overhead cooling, with two separate sub-main lines, cost $5,660 per acre (including material and installation costs).
- ***Shade cloth cost:*** The investment cost for shade cloth installation is $10,000 per acre, with an annual operating cost of $600 per acre for seasonal deployment, removal, and maintenance.
- ***Market price:*** This is the average packed price (price before processing charges are subtracted) of red raspberry in Washington. The market price is assumed constant at $2.40 per pound across all scenarios.
- ***Labor costs:*** Labor rates are $19.82 per hour for manual labor and $20.82 per hour for skilled labor.

Based on the above assumptions, the partial budget analysis compares the net gains for each mitigation scenario relative to the baseline. In Figure 5, added labor cost pertains to labor associated with the deployment and retraction of shade cloth, or additional irrigation and weeding labor for overhead cooling. Other variable costs include berry commission fees, loading and hauling, handling/processing charges, all other operating costs, overhead, and interest. Added fixed cost only includes the additional investment costs for shade cloth or the cost difference between the baseline irrigation system and irrigation system with overhead cooling (see Table 2 for the costs used in the analysis).

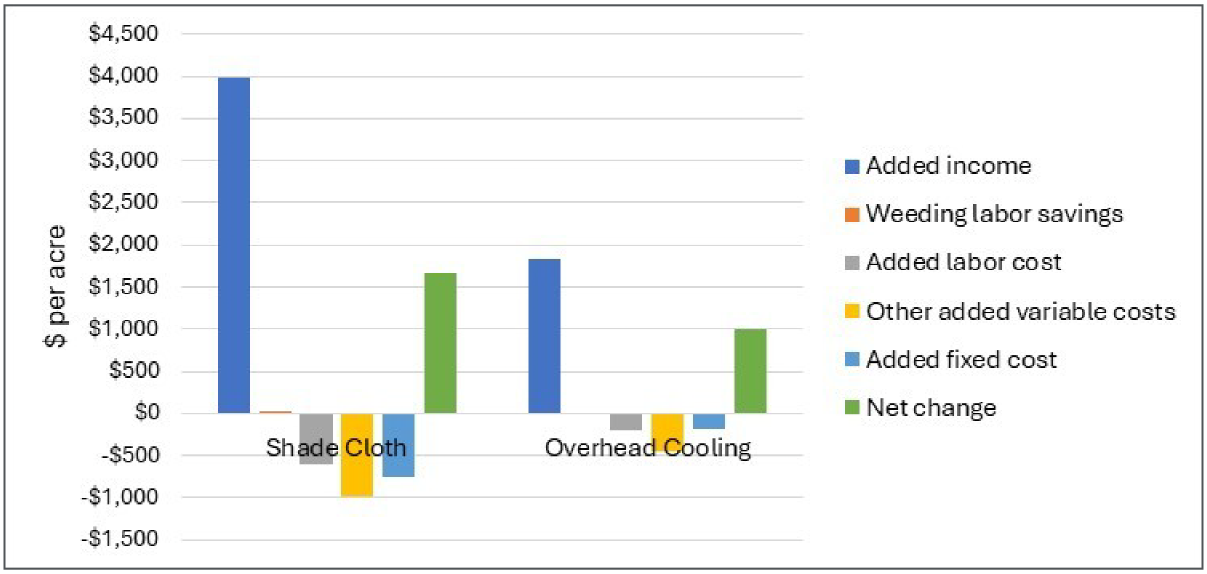

Figure 5. Expected benefits (added income, weeding labor savings), expected costs (added labor costs, other variable costs, and fixed cost), and net changes in profit for each heat mitigation scenario with respect to the 'no mitigation' control under growing conditions with extreme heat events. Data are for Washington processed red raspberry production.

Both strategies increase profits compared to the 'no mitigation' control, with shade cloth yielding a higher net gain—approximately $1,700 per acre compared to $1,000 per acre for overhead cooling. Although shade cloth involves higher additional costs, the additional income—driven primarily by higher yields—more than offsets these expenses. Modest savings in manual weeding labor further contribute to the overall net gain.

These results suggest that shade cloth or overhead cooling can potentially reduce income losses during extreme heat events by minimizing crop damage, making them a valuable tool in growers' risk management strategies. With increasing weather variability due to climate change, the relative value of such mitigation strategies is likely to increase, particularly in regions where yield losses due to heat damage are recurrent.

It is important to note that, although shade cloth or overhead cooling increases yields and total returns relative to the no mitigation control, these gains do not necessarily translate into economic viability. Adoption will depend on whether total returns can exceed total costs, including both operational and capital expenses for the technology. Profitability can be enhanced through lower technology costs, greater yield gains, or supportive policies that offset upfront investment costs, thereby reducing financial risk for growers. Adoption will also depend on compatibility of these mitigation strategies within commercial production practices. For example, mechanization, including machine harvesting with over the row harvesters, will be challenging to integrate with shade cloth. Considering these factors are important to ensure mitigation strategies align with growers' goal of maintaining crop productivity and reducing volatility in farm income under increasing frequency and intensity of heat events.

Other Considerations – Horticultural Practices

Horticultural practices, including selecting heat-tolerant cultivars, cover cropping, mulching, and ensuring adequate irrigation, can support plant health and mitigate the negative effects of extreme heat. Implementing a ground cover, such as a living cover crop in alleyways, can help reduce air temperatures through the transpiration of alleyway plants. This can lead to reductions in air temperature compared to bare soil during hot periods. However, some climates may not be able to maintain alleyway cover crops due to drought and soil compaction caused by farm equipment.

Mulching is effective for conserving soil moisture, moderating soil temperature, and suppressing competition from weeds. The type and color of mulch used can significantly influence field conditions and crop productivity. For instance, black plastic mulch absorbs solar radiation and increases soil and air temperatures, improves water use efficiency, and can increase yields. In contrast, white or metalized mulches reflect light. This can reduce field heat and may be more suitable for mitigating heat stress in hot climates (Sokombela et al., 2025). While colored plastic mulches outperform bare soil regarding weed suppression and impacts on plant growth and yield, choosing the right mulch based on your production goals and environmental conditions is crucial.

Organic mulches, such as compost, manure-based compost, straw, and wood chips, can play a key role in improving soil health over time. They also enhance moisture retention and reduce plant drought stress. Additionally, the type and color of organic mulch can influence its effects on soil temperature and plant health. Dark-colored composts may absorb solar radiation similarly to black plastic, slightly warming the soil. When using compost, it is essential to consider its nutrient contribution and adjust your fertilizer plan accordingly. Follow food safety regulations regarding the timing of raw or manure-based compost applications to prevent contamination. The Food and Drug Administration (FDA) is conducting research on the necessary interval between raw manure applications and harvests to minimize contamination risks. Currently, the FDA supports compliance with USDA Organic Program standards (U.S. Food and Drug Administration, 2024), which requires raw manure incorporation at least 120 days before harvest if the edible crop touches soil, or 90 days before harvest for all other food crops (U.S. Department of Agriculture, n.d.).

Maintaining adequate irrigation based on soil texture and environmental conditions is essential to optimize plant health. However, irrigation alone cannot fully mitigate the effects of extreme heat. Growers are encouraged to work with local crop consultants, irrigation specialists, or extension educators to develop effective horticultural strategies tailored to their fields and growing environments.

Conclusion

Shade cloth and overhead cooling using microsprinklers are proven strategies for reducing damage to small fruit crops like raspberry during extreme heat events. Using one of these methods can lower leaf and fruit surface temperatures, optimize plant hydration status, reduce fruit defects and wilting, and ultimately improve yield and fruit quality. Growers may also benefit by implementing horticultural practices such as using heat tolerant cultivars, cover cropping, mulching, improving soil health and water retention, and strategic irrigation. As heat events become more frequent, it is important to evaluate the costs and benefits of heat mitigation strategies for individual production systems within their unique geographic location. Crop advisors and extension specialists can offer valuable guidance on selecting and implementing the most cost-effective strategies.

Looking toward the future, emerging areas of research showing potential include biostimulants, which may enhance plant stress tolerance to environmental stressors like heat. However, further research is needed into their effectiveness, and currently, they are not recommended for use. Similarly, additional research on the optimal color and density of shade cloth specific to raspberry and blackberry production in the Pacific Northwest is needed to determine the most effective combinations for mitigating heat stress within various geographic areas. At this time, strategies including shade cloth and overhead cooling combined with adapted cultivars and good horticultural practices remain the most reliable tools to help protect crops and maintain productivity under extreme heat conditions.

Website or Social Media Links for Ongoing Updates and Information

- WSU Small Fruit Horticulture program (https://smallfruits.wsu.edu)
- WSU raspberry research (https://smallfruits.wsu.edu/raspberry/)
- Beat the Heat project blog (https://extension.wsu.edu/beat-the-heat/news/)

Acknowledgements

Funding for the work presented in this document was provided by the USDA Specialty Crop Multi-State Program and WSDA Specialty Crop Block Grant Program (Agreement Number: K3888). Additional project support is from the USDA National Institute of Food and Agriculture, Hatch project 7003737, and Washington State University College of Agricultural, Human, and Natural Resources Undergraduate Internship Program.

We would like to thank Casey Gubler, Irrigation Specialist, for their generous contribution to this guide, particularly for providing valuable insights into evaporative cooling strategies.

We would like to thank Jeff Marks, Sales Manager from WaterTech for their generous contribution to this guide, particularly for providing valuable information on considerations related to high iron content in water and its implications for evaporative cooling systems.

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