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FEATURE STORY

Heat Stress Mitigation in Vineyards

MANAGE CANOPIES, IRRIGATION, VINEYARD FLOORS TO REDUCE HEAT

By Ted Rieger

Based on climate trends, average temperatures and the number and duration of heat waves are expected to increase over the next several decades in California. Overnight low temperatures are also increasing, affecting diurnal temperature shifts important for fruit development and quality.

Heat damage to grapevines occurs from elevated air temperature and from direct sunlight heating exposed berries and is exacerbated by vine water stress. These stresses can result in reduced photosynthesis, leaf losses, berry dehydration/losses and the inability to mature a marketable crop. Heat stress and high temperatures can reduce yield and negatively impact berry chemistry and wine quality factors such as sugar levels, acidity, anthocyanins and tannins.

UC Cooperative Extension (UCCE) viticulture specialist Dr. Kaan Kurtural has measured berry skin temperatures of 130 F on black-skinned grapes exposed to direct sunlight at the UC Davis Oakville Station in Napa County. Kurtural said berry temperatures are not just an issue during extreme heat waves. Exposed berries post-veraison can absorb heat and maintain high temperatures up to three hours per day, and these conditions can exist up to two months until harvest.

HEAT MITIGATION STRATEGIES

Mark Battany, UCCE viticulture advisor for San Luis Obispo and Santa Barbara Counties, suggests several strategies to mitigate heat impacts on vines: vineyard/trellis design and row orientation, canopy management, irrigation management and vineyard floor management.

During high heat events with exposed vineyard floors, temperatures are highest near the ground and can be up to 7 F cooler at 5 feet above the ground. "Bare ground when heated by direct sunlight is radiating a lot of heat," Battany said. He advised maintaining cover crop or native cover residue on vineyard floors during the growing season to reduce ground heat accumulation that radiates into the vines. Mowing, rather than tilling, can be more favorable for heat mitigation.

Overhead shade film trial at UCD Oakville Station.
Photo courtesy: S. Kaan Kurtural / UC Davis

Kurtural is conducting vineyard cover crop trials in Oakville and the Central Valley, comparing till and no-till systems for effects on carbon sequestration, greenhouse gas reduction and monitoring temperature and evapotranspiration (ET) for each trial. "Cover crops reduce heat loads in vineyards and the ET of the whole vineyard system is less, particularly early in the year," Kurtural said. A newer hybrid of Poa bulbosa looks promising as a low stature cover crop that forms a thick mat, goes dormant in spring and requires no mowing.

In new vineyard plantings for heat mitigation and mechanization, Kurtural recommends one of two trellis designs – a single high-wire or a high-quadrilateral trellis with catch wire with cordons 60-72 inches above ground level. "Not much vertically shoot positioned (VSP) trellising is going in currently with

Black shade netting can reduce cluster sun exposure and berry temperature. *Photos courtesy: S. Kaan Kurtural / UC Davis*

new plantings, as these high-wire systems place the crop higher above the ground and canopies can be managed with a modified sprawl with more leaf layers to protect fruit from excess exposure," Kurtural said. Suggested row orientation to reduce afternoon exposure is east to west, or northeast to southwest. Battany advises: "Manage the canopy for shading fruit. You have to grow enough canopy in the first place to have enough shade for the fruit."

Using overhead sprinklers or canopy misters to reduce air temperature during heat waves may be an option for some growers. Good quality water is needed to prevent unwanted chemicals from contacting vines and fruit. Applying reflective foliar spray products such as kaolin clay (Surround) or CaCo3 can also protect fruit and canopies from sunburn, heat stress and reduce ET.

SHADE CLOTHS AND FILMS

UC researchers have experimented with shade netting material placed across the canopy fruiting zone on VSP systems at Oakville since 2016. Experiments were performed in 2017 with several colors of ChromatiNet shade material supplied by Ginegar Plastics of Santa Maria on cabernet sauvignon. Data was collected and compared on fruit zone and berry temperatures and berry chemistry at harvest. A four-day heat wave beginning 21 days before harvest had the most impact on exposed clusters in unshaded treatments. Maximum temperatures were 3.9 C higher in exposed clusters resulting in lower acidity, higher pH, and greater losses of anthocyanins and flavonols.

Kurtural said fruit zone shading materials are being used in North Coast and Central Coast commercial vineyards, commonly in older VSP trellis systems with north-south oriented rows on the side of the row with the most sun exposure. Shade netting is installed around veraison and left until harvest. Trials indicate black shade material that allows 40% of solar radiation to pass through provides lower fruit zone temperatures than other shade colors while providing adequate light for favorable berry chemistry.

Trials using overhead shading with infrared filtering films started at Oakville in 2019 with products from Daios Plastics based in Greece and will continue in 2021. Vineyard trials in Greece indicate these films can reduce ambient daytime temperatures from 4-6 degrees C. Based on one season at Oakville, shade film reduced ET up to 30%, reduced canopy temperatures and the overall vine water footprint, and produced fruit with higher concentrations of anthocyanins at harvest compared to untreated control vines. Infrastructure to support overhead shading requires additional costs for labor and materials and may not be practical in some situations.

IRRIGATION DURING HEAT WAVES

"As temperature increases, so does vine ET, and you need to compensate with additional irrigation," Battany said. He advises evaluating the irrigation system's capacity to meet the extra demand of high heat events and designing systems for more extreme conditions if feasible.

UCD assistant professor Dr. Elisabeth Forrestel began trials in 2019 in commercial cabernet sauvignon vineyards on a high-wire trellis at the Borden Ranch (Lodi AVA) to evaluate variable rate drip irrigation applications during extreme heat events, defined as three or more days of temperatures above 100 F. "We use irrigation to promote cooling in vine canopies during heat waves," Forrestel said. In 2019, the trial site experienced two heat waves – one when grapes reached about 50% veraison, and one prior to harvest. In 2020, four heat events occurred – one in May, one pre-veraison and two post-veraison. There were few effects from early season heat waves, likely due to higher soil moisture content. Applied irrigation amounts compared were 60% of ET as the baseline, two times the baseline, and three times the baseline.

Across two seasons of this trial to date, observations indicate that no increase in irrigation – prior to and during a heat wave – results in reduced yield, as well as grape chemistry with higher total soluble solids (TSS) or Brix, higher pH, lower titratable acidity and lower anthocyanins. Increasing irrigation may be unfeasible in some locations in some years due to water supply and drought conditions. In extreme heat stress years, maintaining vine viability for future seasons with minimal irrigation may take priority over producing and ripening crop.

SOIL AMENDMENTS

Compost and soil amendments that enhance the soil microbiome can improve vine root growth, function, water uptake and enhance plant resilience during drought and heat stress. However, amendments alone will unlikely mitigate impacts from extreme heat events. Commercially available products gaining interest and being evaluated in vineyard trials include arbuscular mychorrizal fungi, biochar, and BluVite from Enartis.