PROTECTED VITICULTURE – OPTIMIZING CLIMATE FOR PRODUCTION OF QUALITY WINES

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Climate is the most influential characteristic of vineyards that affects the production and quality of grapes and wine. Regional variations in climate delineate where grapes can be grown and where superior fruit quality can be achieved. Many regions that lack ideal climatic conditions for wine grapes benefit from adoption of vineyard protection techniques. These techniques can prevent or lessen damage from weather events that bring extreme cold, heat, wind or UV exposure; or they can help to optimize vine microclimates to enhance vegetative growth and production of economic yields of mature high-quality fruit for winemaking.

Wind Machines

Many grape growing regions have continental climates with excellent growing season conditions for winegrape production and ripening but can experience extreme cold weather events in fall through spring that cause frost or freeze damage to grapevines (2). These cold events may be infrequent and last only a few hours but can kill leaves, buds or trunk tissues leading to substantial crop loss or vine death.

Wind machines (Figure 1), also known as frost fans, are effective in preventing frost and freeze damage in areas where nighttime temperature inversions occur or where cold air from higher elevations flows into vineyards and pools in depressions on the vineyard floor. Wind machines work by mixing warmer air from several metres above the ground with the cold air at ground level to increase vine micoclimate temperatures to above lethal levels. Wind machines are used to prevent frost damage to leaves and shoots in the spring and fall and freeze damage to dormant buds in the winter. Their effectiveness depends on the strength of the temperature inversion, the depth and breadth of the cold air pool, and the power and location of the wind machine.

Fig. 1: Wind machines reduce freeze damage by drawing down warm air from several metres above grapevine canopies to mix with cold air near the ground.

Growers unsure of timing requirements for wind machine operation often start their machines early in a cold event to ensure success. Wind machines are fuel-consumptive and noisy, similar to a small aircraft, so limiting their operation time is desirable. To study the operation efficiency of wind machines, we used spatial-mesh temperature monitoring systems (1) to characterize the location, size and speed of cold-air pool formation and scouring by wind machines. Air temperature maps (Figure 2) revealed that lethally cold air flowed into the vineyard during the night and within in two hours had pooled into a depression reducing the air temperature by 6 °C to 0 °C. Scouring of cold air from the depression by the wind machine was complete in 45 minutes. These results demonstrated the value of temperature monitoring and revealed that wind machine operation can be delayed until the temperature in the cold air pool reaches the lethal temperature threshold. Application of these findings saves fuel and reduces air pollution and nighttime noise during cold weather events.

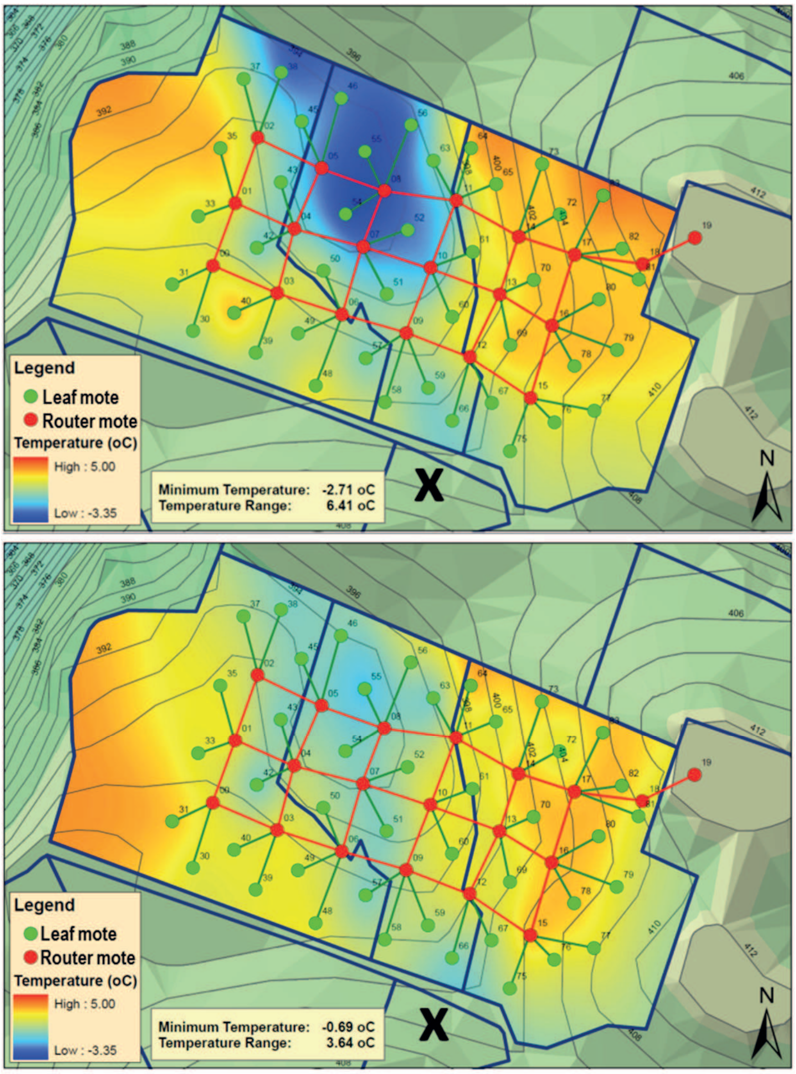

*Fig. 2: Vineyard air temperature before (top) and after (bottom) wind machine (**X**) operation for 45 minutes beginning at 5 am. Leaf and router motes are wireless temperature-sensors in a mesh network used to define spatial variation in temperature. King Family Farm, Penticton, BC, Canada.*

Strong winds that accompany some artic outflow events prevent formation of the inversion conditions required for effective fan operation. Growers may be unsure of the existence and strength of the temperature inversions required for effective wind machine operation. Installing temperature sensors on towers enables detection of inversions and their strength.

The ideal location for a wind machine can be difficult to determine, especially in vineyards having complex terrain with shallow channels and depressions in which cold air drains and pools. These features can be difficult to locate without contour maps with resolution intervals of at least 1 m. Until recently, such maps could be difficult to access or expensive to create. With the adoption of drone acquired terrain elevation data vineyard contour maps can be inexpensively produced. By installing monitoring towers in a grid pattern around low elevation areas air temperature data can be collected in three dimensions for volumetric analysis using an Environmental Visualization System (EVS). EVS mapping of 3-D temperature data shows the size and shape of cold air pools and the strength of inversions (Figure 3) – key information for determining the best location, operation timing and expected effects of wind machines.

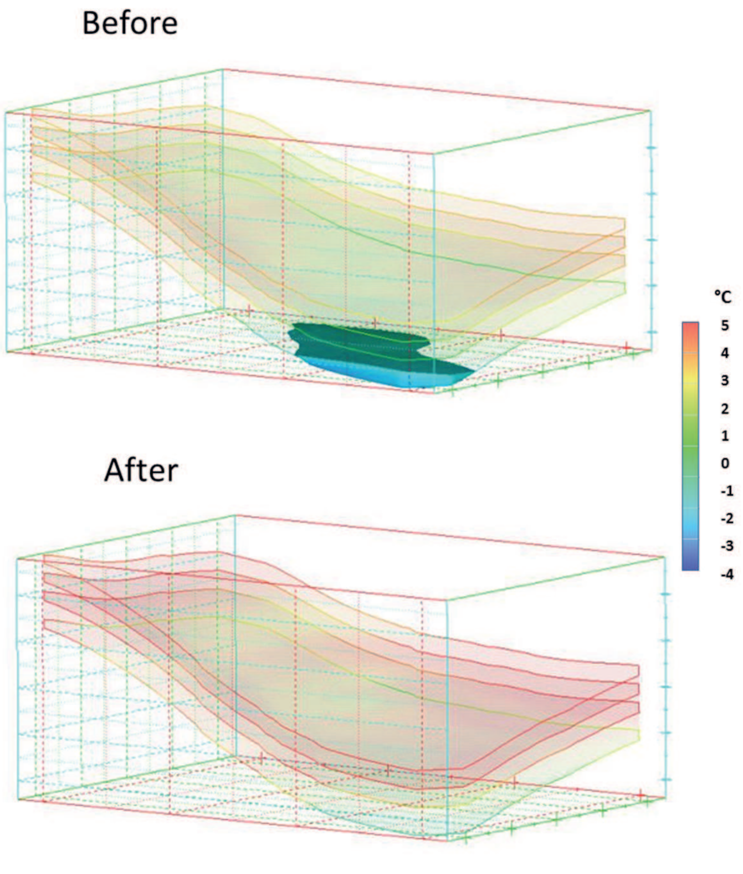

Fig. 3: Results of EVS analysis showing the temperature inversion gradient, and dimensions and temperature of a cold air pool before (top) and after (bottom) wind machine operation.

Over-Winter Protection of Young Grapevines

Young grapevine transplants are particularly vulnerable to freeze damage or kill due to their small size and emersion in cold air pools on the vineyard floor. In many cold-climate viticulture areas young vines are hilled up with soil to protect their stems and roots from cold damage. The soil cover conducts heat from deep in the soil, preventing heat loss from vine tissues. While this practice is effective drawbacks include mechanical damage to vine roots, soil structure and floor vegetation communities, and infection by rot-diseases that can kill buds.

We studied the effects of alternative inexpensive protective covers on the temperature of young vines and shoots in winter. The covers included empty and sawdust filled 2-L cardboard cartons, mounded sawdust, and foam insulation wrap (Figure 4).

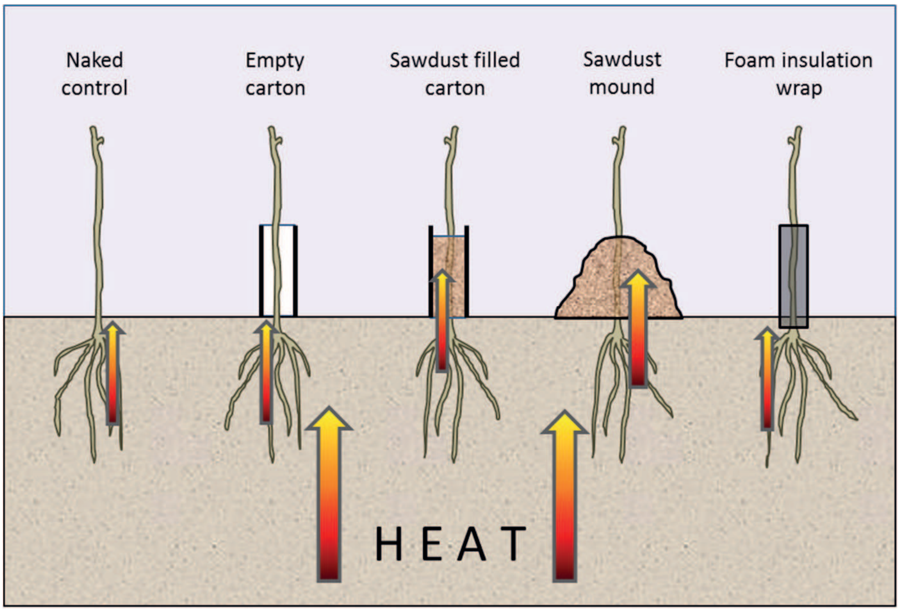

Fig. 4: Over-winter treatments to protect young grapevines from freeze injury. Mounded sawdust most effectively conducts ground heat to increase trunk temperatures. Foam insulation prevents conductance of ground heat and provides no protection.

Daily minimum temperatures of stems and roots were similar for non-protected (control) and empty-carton covered vines, and in comparison vines were up to 1° C warmer in sawdust filled cartons, up to 5° C warmer in mounded sawdust, and up to 1° C cooler in foam insulation wrap. Snow cover further increased the minimum temperatures of vines mounded with sawdust. Wrapping vines with foam insulation increased their daytime maximum temperature by up to 6° C but decreased the nighttime minimum temperatures by up to 4° C compared with bare vines. Hilling vines with sawdust was the most effective in increasing stem temperatures at night, but over the winter some buds died that had been buried in sawdust.

Plastic Film Enclosures for Vine Canopies

Many cool climate viticulture regions, especially those with maritime climates, lack sufficient growing season heat to optimally ripen premium winegrape varieties. Harvested fruit is low in sugar and high in acidity, and finished wines often have harsh unripe tannins and green herbaceous flavours and aromas.

Daytime air temperature around buds, and developing shoots and clusters can be increased by applying plastic film enclosures to reduce convective heat loss. We studied the impacts of polyethylene film enclosures on Merlot fruit phenology, maturation, and quality at harvest (3, 4).

The enclosures (sleeves) were installed on the vines in early April, about three weeks before the normal time for budbreak (Figure 5). The sleeves were perforated at top for ventilation, and five weeks after installation they were further ventilated by adding bottom openings. At seven weeks the sleeve tops were cut open to allow for shoot growth and acclimation to ambient climate (Figure 6), and a week later, in late May, the sleeves were removed.

Fig. 5: Polyethylene sleeve enclosures installed on Merlot grapevines in the Okanagan Valley in British Columbia.

Fig. 6: Polyethylene sleeves installed on Merlot grapevines. Tops are opened for ventilation and shoot acclimation.

Over the 8 weeks of installation growing degree day (GDD) accumulation was 110 higher in the sleeves. Compared with ambient conditions, maximum daytime air temperature averaged 8 °C higher but minimum nighttime temperatures averaged 2 °C lower. Budbreak was advanced by one week (Figure 7), and bloom by 10 days. The earlier bloom which occurred after the sleeves were removed, was under cooler conditions than for vines not covered, and led to a reduction in fruit set and in yield from 7.6 to 6.8 kg/vine. The sleeve treatment advanced fruit maturation by more than three weeks. At harvest berry soluble solids was increased from 21.6 to 24 °Brix and titratable acidity was reduced by 1 g/L.

Fig. 7: Advanced budbreak and shoot growth on a grapevine cane segment within a plastic sleeve enclosure.

Fig. 8: A grower-fabricated plastic enclosure applicator.

These results show the importance of early season heat in attaining desired fruit quality at end of season. The main drawback of using this technique in cool continental climates is the reduction in nighttime temperatures within sleeves that increases frost damage risk. These enclosures may be more suitable for maritime regions where frost risk is lower in late spring, and heat limits to optimum vine and fruit development extend through the growing season.

Literature cited

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