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Heat and water stress in Kentucky Vineyards: Effects on the vine and wine

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Grapevines are deep rooted and generally have the ability to find water in periods of drought. However, the 2012 season has brought below average rainfall totals and extremely high temperature spikes and Kentucky vineyards should be closely monitored for symptoms of water stress. This is especially true for newly established vineyards. A mild degree of stress is not harmful, but severe stress can reduce crop level and delay fruit ripening, potentially harm fruit quality and vine health of both current and subsequent vintages. Mild water stress occurring between bloom and veraison may be beneficial to reduce vegetative vine growth and canopy shading. However, high levels of water stress on the vines occurring between veraison and harvest is less desirable due to its negative impact on fruit ripening and potential wine quality. Water availability post-veraison is important for the vine to maintain ideal photosynthetic rates responsible for ripening fruit, with heavily cropped vines requiring more water for ripening than do lightly cropped vines.

Recognizing water stress

Knowing how to monitor a vineyard for apparent vine water stress will be critical during years of high heat and low rainfall. Drought stress will initially appear in areas of the vineyard having restricted rooting depth and lower water holding capacity. During periods of water stress vines will transport water and nutrients from the older, basal leaves to newer shoot and leaf growth as well as to developing clusters. Vines suffering from water stress will initially express symptoms of nutrient deficiency in basal leaves, potentially resulting in leaf loss (Fig. 1).

Figure 1. Leaf scorching of basal leaves due to water stress.

Figure 2. Grapevine showing shoot tip death and wilting of the basal most leaves.

Other symptoms of water stress include increased leaf temperature, wilting, leaf scorch, and suppressed growth and death of shoot-terminals and tendrils (Fig. 2).

The underside of the grape leaf contains pores called stomata. In a well-watered grapevine these stomata are allowed to remain open and serve to control both the outward flow of oxygen and water vapor (providing leaf cooling) and the ingress of CO_2 gas (required for photosynthesis). In order to conserve water during abnormally hot and dry conditions the leaf's stomata remain closed. Sun-exposed leaves of water stressed vines are therefore less capable of cooling themselves and may reach temperatures well over 100˚F. Such leaves will feel warm to the touch, so simply walking through the vineyard and feeling large leaves receiving direct sunlight can be a quick and useful tool to identify the occurrence of water stress.

Canopy management during periods of high temperature

Canopy management operations such as late season shoot positioning and leaf pulling must

be done carefully so as not to result in sudden high levels of fruit exposure to direct sunlight. When accomplished late in the season, during periods of warm temperatures, manipulations of canopy density achieved by either shoot positioning or leaf pulling may result in fruit burn (Fig. 3). If fruit has not previously been exposed to sunlight from the time of fruit set, substantial defoliation leading to direct cluster exposure to sunlight may cause fruit sunburn, resulting in injury to developing berries that will reduce cluster weight (due to berry abscission) and may also increase the risk of fruit rot on berries that are damaged but fail to abscise.

Figure 3. Effects of combing and shoot positioning of Traminette vines done during a period of abnormally high daytime temperatures.

Effect of water stress on wine quality

As well as having negative impacts on vine performance excessive water stress from veraison to harvest may lead to poor wine quality including reduced aging potential. Water stress that occurs during the four weeks around veraison (when fruit demand for both nitrogen and water is high) has been linked to atypical aging "ATA" of wines. Wines made from vines experiencing drought conditions around veraison typically express reduced varietal aroma and increased off aromas reminiscent of "dirty dish towel" and "floor polish". During years of abnormally low rainfall water stressed vines typically produce fruit with lower than average yeast-available-nitrogen (YAN) that require supplemental additions of nitrogen to the fermenting must in order to prevent reduced aromas including hydrogen sulfide (H_2S).

Mid to late-season canopy management and wine quality

The degree of fruit exposure provided by canopy management can have a dramatic effect on wine quality. Exposure to sunlight is especially important for development of flavonoids, natural sunscreen compounds that are key to the

development of both color (anthocyanins) and flavor compounds (quercetin and catechins) in resulting wines. In warm grape growing regions such as Kentucky, sunlight exposure to developing clusters early in the season is especially important. Although, increasing amounts of sunlight exposure to developing grape clusters is generally thought to improve color and aroma compounds responsible for the production of high quality wine, it is possible to have too much of a good thing. Transpiration rates of developing grape clusters are dramatically reduced as berries begin to accumulate sugar, therefore after veraison grape clusters are less and less able to regulate their temperature. Overexposure of maturing fruit during periods of warm weather often leads to unwanted increases in fruit temperature (as much as 20^{o}F above ambient temperature) that typically results in reduced color, aroma, and acidity of wines made from such fruit. This is especially true for early ripening cultivars harvested during the warmest part of the season. For most cultivars an ideal canopy would express between one and two leaf layers with nearly 50% of clusters visible from outside the vine canopy (Fig. 4). The exception to this rule may be 'Norton', due to its tendency to express high levels malic acid, with higher levels of fruit exposure leading to more manageable levels titratable acidity at harvest.

Figure 4. Grapevine expressing appropriate leaf density and cluster exposure.

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