University of California Cooperative Extension # Tulare County

Grape Notes

March-April 2002

DOV Raisin Discussion and Shoot Thinning Demonstration

UC Kearney Research and Extension Center
9240 South Riverbend Avenue
Parlier, California

Friday, April 12, 2002

No charge for attendance. Pre-registration not required.

9:30 a.m.	Register and move to demonstration site
10:00	DOV using a traditional trellis: general discussion and demonstration of shoot thinning
	Being prepared to handle high moisture raisins: on-farm drying and dehydrators

Bill Peacock, Steve Vasquez, and Fred Swanson, UC Farm Advisors and Kearney Research and Extension Center Superintendent, respectively Wayne Albrecht, Albrecht Farms, and Mike Moryiama, Sun Maid

12:00	Adjourn

4437-B SOUTH LASPINA STREET, TULARE, CALIFORNIA 93274 • TELEPHONE (559) 685-3303 • FAX (559) 685-3319
U.S. Department of Agriculture, University of California, and Tulare County Cooperating

Table Grape Berry Growth and Development: A Review

Nick Dokoozlian, Department of Viticulture and Enology
University of California, Davis

Fruit set in most table grape cultivars is defined as the stage when berry diameter is between 4 and 5 mm. In seeded varieties, such as Redglobe, fruit set occurs after pollination and fertilization are successfully completed and seed development is initiated. Each berry may contain up to 4 seeds, but usually there are less. However, two other fruit set mechanisms occur which allow seedless or seemingly seedless berries to form. The first mechanism is referred to as parthenocarpy, the only method by which truly seedless berries are produced. With this mechanism only the stimulus of pollination, or the presence of pollen on the stigma, is necessary for berry set. Parthenocarpic berries exhibit no ovule and hence seed development after anthesis. The lack of normal ovule development is attributed to defective embryo sac formation. An example of a parthenocarpic variety is Black Corinth, the grape used to produce Zante Currant raisins. The second mechanism, stenospermocarpy, results in the formation of berries that appear to be seedless. In this case pollination and fertilization occur as normal, but the embryo aborts two to four weeks after fertilization. The ovary wall (pericarp) or berry flesh continues to grow, however, seed development ceases following embryo abortion. The result is partially developed seeds or seed traces within the berry. Despite the presence of seed traces, stenospermocarpic berries are generally considered seedless for commercial purposes. All commercially important seedless table grape cultivars set their fruit stenospermocarpically, including Thompson Seedless, Flame Seedless, Crimson Seedless and Autumn Royal.

Significant variation in the detectability of seed traces is observed among stenospermocarpic varieties. For example, Thompson Seedless contains small, soft seed traces that normally go unnoticed. In contrast, Black Monukka contains large, hard seed traces easily detectable in fresh or dried fruit. Seed trace development can also be variable in some varieties, for example Flame Seedless, such that they can be detected in some seasons but not others. Many factors influence the detectability of seed traces in stenospermocarpic varieties, including their size, degree of development, the time of embryo abortion and the number of fertilized ovules. Embryo abortion generally occurs during the early stages of fruit growth in varieties with small seed traces, while the process may occur later in varieties with large seed traces. Thompson Seedless berries were reported to develop prominent seed traces during a season when temperatures during bloom and the early stages of fruit growth were significantly below normal. It is believed that unusually cool temperatures during the early stages of fruit growth delay embryo abortion, increasing the number of noticeable seed traces. Several other factors influence seed trace development, including rootstock and season. For example, earlier studies indicated that when the raisin cultivar Fiesta was grafted to Harmony or Freedom rootstock it produced fewer but larger (on a dry weight basis) seed traces per berry compared to when it was grafted to Thompson Seedless. Vine age may also play a role, as mature vines (greater than 8 years old) are reported to produce berries with fewer seed traces than young vines. This has been noted on both Flame Seedless and Autumn Royal.

Climatic factors have a significant effect on fruit set. Due to inhibition of pollen tube growth and ovule fertilization, fruit set is greatly reduced when temperatures fall below 65 or exceed 100 ^{o}F during set. Cold temperatures are often associated with incomplete detachment of the calyptras, while both cold and hot temperatures may reduce fruit set by preventing growth of pollen tubes and ovule development. Rainfall or high humidity may reduce fruit set by causing poor pollination due to incomplete detachment of the calyptras. Rain can also dilute the stigmatic fluid, thus interfering with the germination of pollen grains.

Following fruit set, the grape flower ovary develops into a fleshy berry. The grape berry is a simple fruit, consisting of two locules or seed cavities surrounded by an ovary wall (pericarp). In seeded varieties there may be up to 4 seeds. In the case of stenospermocarpic varieties, the locules contain seed traces resulting from the abortion of the ovules early in their development. The stylar remnant or scar is present at the berry apex, opposite the pedicel or capstem. The cuticle, a thin wax coated secretion of lipids, covers the berry surface. The fleshy pericarp consists of an exocarp or skin of 6 to 8 cell layers, and a mesocarp or plup of 25 to 30 cell layers. For most seedless varieties, the mesocarp accounts for 85 to 90% of berry fresh weight. The vascular system of the berry includes dorsal (peripheral), ventral (central), and ovular vascular bundles. The vascular bundles contain the xylem and phloem tissues through which water, sugars and other substances are supplied to the berry.

Increases in berry weight, volume or diameter during development are typically characterized by a double sigmoid curve resulting from two consecutive stages of growth separated by a phase of slow or nil growth. Grape berries advance through three distinct stages of development during their growth:

Stage I - the first phase of rapid berry growth. Immediately following bloom, a period of rapid berry growth is observed. During this period berry growth results from both cell division and cell enlargement. Berry texture is firm, while berry color is green due to the presence of chlorophyll. The sugar content of the berry remains low, while organic acids accumulate. This stage lasts between 3 and 4 weeks for most raisin grape varieties grown in the central San Joaquin Valley.

Stage II - the lag phase of berry growth. Berry growth slows markedly during this period, while the organic acid concentration of the berries reaches its highest level. Berries remain firm, but begin to lose chlorophyll. The lag stage normally lasts between 2 and 3 weeks in the central San Joaquin Valley, depending upon the season and variety.

Stage III - the second phase of rapid berry growth and fruit ripening. The resumption of rapid berry growth and initiation of ripening commences with the beginning of this stage. The phrase "berry softening", or the French term "veraison", which characterizes the initial stages of color development, are commonly used to describe the striking changes in fruit characteristics which occur at the initiation of stage III. Berries soften and lose chlorophyll, while in colored varieties red pigments begin to accumulate in the skin. Sugar begins to accumulate and the concentration of organic acids declines. Aroma and flavor components accumulate in the fruit. Berry growth during this stage is limited to cell enlargement, and normally lasts between 6 and 8 weeks.

Potential berry size or fresh weight is controlled by three principle factors: cell number, cell volume and organic solute (sugar) content. The number of cells in a grape berry is established during the first three weeks following anthesis, as no further cell division occurs after this period. In fact, the number of cell divisions prior to anthesis is the primary determinant of cell number per berry. Cell volume increases significantly during stage I, remains relatively constant during stage II, and resumes rapid expansion in stage III. The concentration of organic solutes (primarily sugars) per unit cell volume also increases sharply during phase III. Cell volume increases about 300 fold between anthesis and harvest, while the content of organic solutes per unit cell volume increases four fold during the same period.

Temperature influences both cell division and enlargement, with the optimum temperatures for berry growth ranging between 68 and 77 ^{o}F. Berry growth during stage I is quite sensitive to temperature, with temperatures exceeding 95 ^{o}F reducing growth rate and size at harvest. Light is also important for optimum berry growth. Berries grown under heavily shaded conditions immediately after berry set are significantly smaller than berries well exposed to light. This suggests that light stimulates cell division and/or cell expansion in grape berries during stage I.

Vines undergoing water stress during stage I normally produce smaller berries than non-stressed vines. The effects of water stress during stage I on berry growth cannot be reversed by subsequent watering, and recent work indicates that this occurs due to permanent reductions in cell size or volume. Water stress during phases II and III may also decrease berry weight, however, the reduction is related to reduced cell volume and/or diminished solutes (sugar) per cell. Nutrient deficiencies or other disorders that reduce photosynthesis may also reduce berry growth or slow ripening by decreasing the supply of sugars to the fruit.

Anthocyanins are water-soluble vacuolar pigments responsible for the violet, purple, red and scarlet colors of table grapes.They are produced from carbon and other photoassimilates imported into the berry via the phloem, and all enzymes necessary to produce these pigments have previously been found in the berry skin of *Vitis vinifera*. It is currently believed that the location of anthocyanin synthesis within the cell is near the endoplasmic reticulum. Pigments produced in the cytoplasm are then imported into the vacuole via specialized vesicles called anthocyanoplasts. The distribution and concentration of anthocyanins in grape berries depends greatly upon the variety and degree of maturation. In most grape cultivars anthocyanins are located only in the hypodermis of the berry skin, although they can also be present in the pulp of teinturier cultivars (ex. Alicante Bouschet). Anthocyanin accumulation normally increases rapidly at the beginning of veraison or berry ripening, and then slows as the fruit reaches maturity. Under some conditions a slight decrease in anthocyanin concentration has been reported when fruit reaches the overripe stage. Anthocyanin synthesis and accumulation in grape berries are influenced by a wide variety of environmental and vineyard management factors including light, temperature, nutrition, crop load, canopy management and plant growth regulators.

The major anthocyanins commonly found in *Vitis vinifera* grape berries consist of the 3-monoglucosides and 3-p-coumarylglucoside derivatives of the following five pigments: cyanidin, peonidin, delphinidin, petunidin and malvidin. The color and intensity of grape berries is determined by the relative amounts of each of these pigments present in the skin. For example, the dominant pigment in black-colored cultivars such as Ribier and Fantasy Seedless is malvidin, although delphinidin and peonidin are also present. The red-colored Emperor has equal amounts of malvidin and peonidin, while the scarlet or flame-colored berries of Tokay contain only cyanidin. The synthesis (including enzymatic regulation) and accumulation rates of each pigment varies significantly based on their relative sensitivities to both environmental and cultural factors. For example, cyanidin is extremely sensitive to both temperature and light. Cyanidin dominant cultivars, such as Tokay, require cool night temperatures to achieve accumulate large amounts of pigment.Tokay berries accumulate large amounts of pigment when exposed to the cool delta breezes of the northern San Joaquin Valley, but remain green when grown under warmer night temperatures of the southern San Joaquin Valley. Peonidin, the pigment found in the skin of Cardinal grapes, is also very sensitive to both temperature and light. In contrast, pigment accumulation in malvidin dominant cultivars such as Ribier is generally much less affected by environmental conditions compared to either Tokay or Cardinal.

Unfortunately, the last major survey characterizing the pigment composition of table grape cultivars in California was performed in the early 1970's, long before the introduction and commercial adaptation of modern cultivars such as Flame Seedless, Crimson Seedless, Redglobe and others. This information is needed in order to explain why certain cultivars are difficult to color, as well as identify which pigments should be avoided or more fully utilized when breeding new cultivars. Another important area of future work is to determine how plant growth regulators such as GA, CPPU and ethephon impact the anthocyanin composition of important cultivars. While it is clear that GA and CPPU reduce berry color, work is needed to determine if they reduce accumulation of all pigments equally or if only certain pigments are affected. Similarly, it is not known if ethephon enhances berry color by increasing the accumulation of all pigments or a select few. This information is essential if we are to understand how to better manipulate berry color with cultural practices.

Bill Peacock
Viticulture Farm Advisor
(559) 685-3309, Ext. 217