mid-July shows promise.

Grape dehydration began in California as a way to salvage raisins when sun-drying conditions were unfavorable. Interest remained low until about 1925 when a new type of raisin, the golden Thompson, was introduced to compete with the light-colored Smyrna raisin produced in other countries. By the late 1930s approximately 25,000 tons of golden raisins were produced each year. During the period of expansion University research elucidated principles that resulted in the design of more efficient dehydration equipment and facilities. Investigations of sulfuring, dipping, and drying procedures and their effects on the vitamin content led to improved raisin quality. From concurrent studies of insects that attack stored raisins and other dried fruits sanitation procedures and fumigation techniques were developed and refined.

The University has given special attention to the cost of establishing a raisin variety vineyard and of producing raisins through a series of studies updated every two years beginning in 1959. Sample costs enabled growers to compare expenses and identify high costs, and also stimulated better record-keeping as a means of maximizing returns on investment. The future export market for California raisins in Europe was evaluated as early as 1963 with the establishment of the European Economic Community (EEC). This subject remains a concern today with the impending entry into EEC of Greece, a major raisin producer.

The large demand for hand labor during the raisin harvest and pick-up period from late August to early October has been of continuing concern to the industry. In 1959 University investigators used time-and-motion study techniques to find ways to increase picker efficiency; they recommended the use of a tray carrier, for example. Later an analysis of mechanical aids for raisin pick-up and boxing and bulk handling methods in Fresno County led to greater handling efficiency. Overall costs, labor inputs, and hand-lifting needs were lowered. A new technique for vine-drying and machine-harvesting Black Corinth raisins was introduced in the early seventies. The resulting raisins were more attractive and had better flavor than those hand harvested and dried on trays between rows.

Studies on mechanical harvesting of Thompson Seedless raisin grapes by means of vibration after cane severance began in 1968. Severing the fruiting canes caused water loss and other physical changes in the capstems and berries that permitted machine harvest as single berries. The berries were mechanically conveyed and spread in a single layer on a continuous tray for rapid sun drying in the vineyard. Cane severance reduced mechanical damage and stickiness of raisins when machine harvested. Researchers completed an evaluation of methods for severing fruiting canes of Thompson vines in 1973. Crew productivity was enhanced by the use of pneumatic pruning equipment. This new method of harvesting and drying raisins is in an early stage of adoption by raisin growers; acceptance is slow because of the large numbers of small-size raisin vineyards.

Raisin quality has been investigated in detail since the early sixties. The sugar content of grapes at harvest and the average berry weight were correlated with airstream sorter quality grades. The airstream sorter was developed as a replacement for visual grading for quality to save time and eliminate human bias. Harvesting more mature grapes improved raisin quality, reduced harvest costs, and raised yields. The latest research showed that bloom-applied gibberellic acid increased grape berry and raisin weights but did not affect grape maturity or airstream sorter raisin grades.

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Controlled-climate research

Essentially all the controlled-climate research with grapevines in California has been done in the past 20 years. A stationary and a rotating phytotron unit became available in 1961 and 1965, respectively, for plant research at the University of California, Davis. The phytotron rooms precisely control day and night temperatures as well as humidity. Solar radiation is the source of light and can be controlled to some extent with shade fabrics, filters, and the like. More recently, large temperature-controlled water baths have been added to the rooms so that root and air temperatures can be varied independently of each other and their interaction studied.

Physiological studies have been concerned mainly with the influence of temperature and light on fruit coloration, photosynthesis and fruit and vine growth, budbreak and fruit-set, inorganic and organic composition of fruit and nonfruiting parts of grapevines, and enzymes involved in organic acid and nitrogen metabolism.

The first controlled-climate work done in California dealt with the influence of light on fruit coloration. When light was excluded from the clusters, the table grape varieties Tokay, Sultanina Rose,

Far left: Viticulture students measure shoot growth of Cabernet Sauvignon grapevines inside the phytotron in a study of effects of temperature on activity of a growth regulator.

Left: Phytotron rotates on a pedestal, keeping light at a constant intensity all day. Grapevines grown inside can be studied under precisely controlled temperature, humidity, and light.

and Emperor failed to color, whereas red and black wine varieties showed color.

More recently my colleagues and I found that low levels of solar radiation (less than 500 foot-candles) or high temperatures (greater than 30° C or 86° F) during either the day or night decreased or completely inhibited formation of anthocyanin (red) pigments in the skins of grapes. Temperatures of 15° to 20° C (59° to 68° F) during the day or night were highly conducive to good fruit coloration. Examination of individual anthocyanins by paper or thin-layer chromatography showed that cultivars in which either cyanidin (reddish orange) or peonidin (reddish) were the main pigments present were most affected by low light or high temperatures. In some cultivars, such as Emperor or Tokay, high day/night temperatures (37°/32° C or 100°/90° F) caused permanent loss of the ability of fruits to form anthocyanins when wines were returned to favorable climatic conditions, even though sugar accumulation was little affected.

High levels of nitrogen fertilization and low ratios of leaf area to crop weight reduced fruit coloration. Recent studies showed that in some cultivars, such as Cardinal, much of the inhibitory effect of low light on fruit coloration could be replaced by application of ethephon (a compound that releases ethylene gas and improves fruit coloration) when grapes begin to ripen.

unlocks growth secrets

W. Mark Kliewer

Phytotron studies with Thompson Seedless at different day temperatures and light intensities demonstrated that maximum gain in dry weight and carbohydrate accumulation occurred at 30° C under high light (greater than 2,000 foot-candles) and at 20° C under low light (less than 400 foot-candles).

Day temperature of 25° C (77° F) during the bloom-set period was much more favorable for fruit-set, ovule fertility, and berry growth and weight than temperatures above 32° C (90° F). The larger berry size that developed at 25° C (77° F) than at 35° or 40° C (95° or 104° F) was attributed to a greater number of cells in the fleshy pericarp tissue.

For the past five years we have studied the effects of root temperature on budbreak, shoot growth, and fruit-set of Cabernet Sauvignon vines grown on their own roots as well as on different rootstocks. The time and amount of budbreak and shoot growth were significantly greater at 25° to 30° C than at 11° to 15° C root temperatures. As root temperature increased from 15° to 35° C the percentage of dry matter decreased in stems but increased in leaves. Root temperature of 12° to 30° C had relatively little effect on fruit-set. Fruit-set of Cabernet Sauvignon on St. George rootstock was about half that of vines on AxR, SO4, or own-rooted at all root temperatures.

Beginning in 1964 we studied the influence of air and root temperature and light intensities on organic and inorganic constituents of grapes and on the resulting fruit quality. Low air or root temperatures (15° to 20° C) caused markedly greater total titratable acidity (mainly due to increased malic acid formation) than did higher air or root temperatures. The lower the air temperature, the greater the proportion of the total acidity due to malic acid. Furthermore, the rate of decrease of malic and tartaric acids as fruit matured was dependent on temperature and cultivar, but relatively independent of light intensity; malic acid always decreased at a greater rate than tartaric acid.

High air and root temperatures increased the proportion of malate and tartrate present as salts, especially dibasic salts, with potassium the principal cation. Low air and root temperatures generally decreased pH, arginine, proline, potassium, total nitrogen, and cytokinins in fruits. Low light intensities (less than 1,200 foot-candles), on the other hand, usually reduced total soluble solids, pH, and proline and increased levels of total acidity, malate, arginine, and total nitrogen in berry juice when compared with grapes grown at high light intensities.

In several studies, the microclimates of vineyards in California's interior valleys have been modified by overhead sprinklers or artificial shade screening with the objective of increasing fruit quality for wine production. Although both methods generally increased total acidity and fruit coloration and reduced pH of berry juice, other problems such as delayed sugar accumulation, development of bunch rot, and likelihood of must to become oxidized have shown that these methods are not commercially practical at present. The level of soluble solids of berries receiving direct radiation from the sun was slightly less than that of fruit not directly exposed to solar radiation. The temperature of "sun" berries was 2° to 10° C higher than that of "shade " berries.

In biochemical studies on effects of temperature and light on activities of enzymes associated with malic acid, arginine, and nitrate accumulation and degradation we found that from the simultaneous action of malic-acid-producing enzyme and malic-acid-degrading enzyme systems at different temperatures, the greatest tendency for malic acid accumulation in immature grape berries was at 20° to 25° C. As temperature increased from 10° to 40° C, the malic acid metabolic pool size decreased, indicating that turnover of this acid was favored at higher temperatures and synthesis at lower temperatures. The amount of net dark CO_2 fixation was related inversely to malic acid concentration in the berry.

More recently we isolated and determined the optimum reaction conditions of all the enzymes associated with the ornithine-urea cycle in Chenin blanc seedlings and the pathway for arginine formation and degradation. The optimum temperature for each of the enzymes in the urea cycle—orithine carbamoyltransferase, arginosuccinate synthetase and lyase and arginase—was 38° to 40° C. Arginine is the principal form in which nitrogen is stored in woody tissues of grapevines and can be used to indicate the nitrogen status of grapevines.

Controlled-climate investigations with grapevines remain an active area of research to determine the optimum climatic conditions as well as conditions that limit processes important in determining fruit and wine quality.

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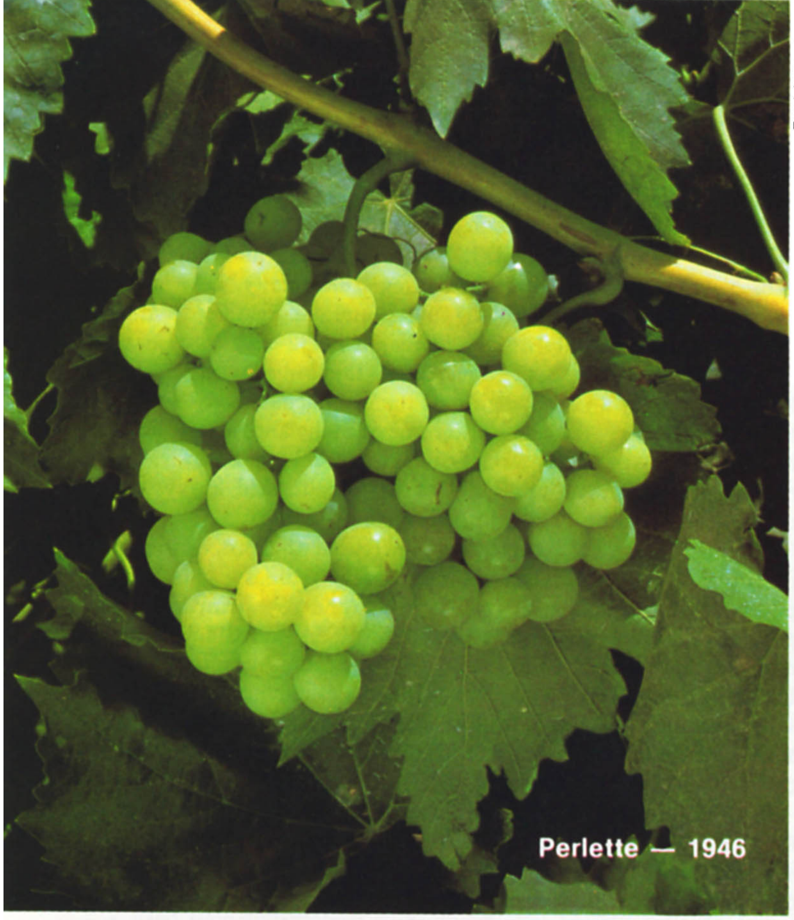

Perlette — 1946

Fred Jensen

Jewelers' forceps and binocular magnification are needed to remove fragile flower stamens before applying pollen of desired male parent in effort to breed improved new grape variety.

A. N. Kasimatis

Queen — 1954

Ruby Seedless — 1968

Fred Jensen