26

Harvesting and Handling

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The basic methods of hand harvesting and drying grapes for natural raisins have undergone only moderate changes since the early practice of tray drying. Most of the changes have concerned the tray materials used for drying and the modernization of equipment and handling methods. This includes greater options in paper tray materials and sizes, mechanical pickup of raisin rolls or continuous paper trays, bulk handing in bins, and the mechanical shaking and cleaning of raisins on the farm before delivery. The development of on-farm dryers by growers and raisin reconditioning equipment by manufacturers and raisin packers has reduced fruit losses associated with rain.

Most hand-harvested raisin grapes are dried on individual paper trays. When drying is complete, they are rolled, picked up mechanically or by hand, and dumped into bulk containers for removal from the field. Raisin-making practices remain relatively uncomplicated: they require a limited amount of specialized equipment, depend on solar energy for most of the drying, and produce a natural, easily handled and stored product. However, the practices are labor intensive, require close supervision and experienced management, and involve weather risks.

DECIDING WHEN TO HARVEST

Date of harvest is one of the most important decisions in raisin production. The grower needs to consider the four most important production factors—yield, quality, rain risk, and availability of labor—simultaneously.

Yield

Two major changes occur after berry softening (veraison) and as the grapes ripen. Soluble solids (sugar) increase while the berries are continuing to grow and expand due to the influx of water. During this time, berry growth and soluble solids increase linearly at about 1 to 1.5 °Brix per week. This is accompanied by a fresh crop weight increase of about 5 percent per week. The rate of this accumulation can be altered by weather, crop load, and vine canopy conditions. For example, sudden hot spells, large crops, or insect damage can slow this process. As berries reach full maturation, their growth and soluble solids accumulation tend to slow and reach a maximum, usually in early to mid-September (Figure 26.1). In some cases, soluble solids per berry may continue to increase for a week or two after the berries have stopped growing. Thereafter, increases in soluble solids concentration may be largely due to the loss of water from the berries and the concentration of solids already present in the berries. At this point, fresh yields will actually decline while raisin yields level off. A further delay in harvest, espe-

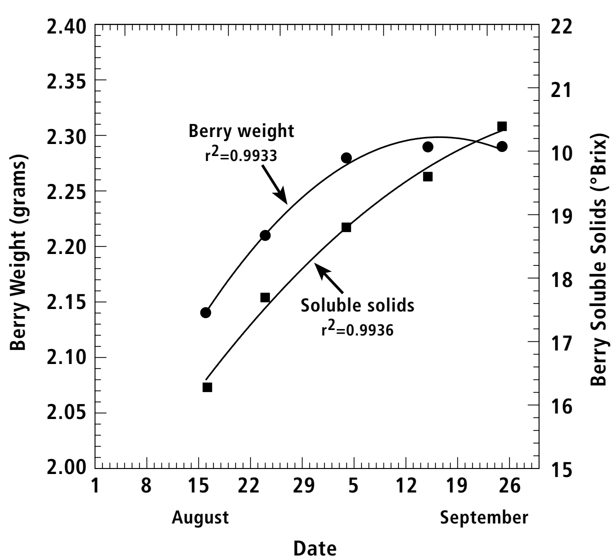

Figure 26.1 Berry changes during the harvest period (3-year average, 'Thompson Seedless' vineyard)

cially after mid-September, may result in raisin yield losses to berry decay and shatter.

Once harvested, the biggest change that occurs as the grapes turn to raisins is the loss of water. These raisins, when dried down to 15 percent water, will contain about 74 percent sugar by weight. Hence, the greater the percentage of sugar in the fresh grapes, the greater the raisin yield.

Drying ratio. The amount of raisin weight or yield obtained from a given amount of fresh grapes is the *drying ratio*. To calculate the drying ratio, divide the fresh weight of the grapes by the dry weight of raisins (adjusted to 15 percent moisture). This ratio is mostly influenced by grape sugar content. For example, grapes harvested at 18 °Brix have a drying ratio of about 4.63:1 (4.63 pounds of fresh grapes yield 1 pound of raisins). In contrast, 22 °Brix grapes have a drying ratio of about 3.74:1. A comparison of raisin yields would show that 9 tons of grapes testing 18 °Brix would yield 1.94 tons of raisins while the same amount of grapes at 22 °Brix would yield 2.41 tons of raisins.

The relationship of grape maturity to drying ratio over a wide range of soluble solids is shown in Figure 26.2. The data are from a study conducted in 11 different commercial 'Thompson Seedless' vineyards in Fresno and Madera Counties over five harvest dates for 6 years. It shows a highly significant curvilinear relationship for soluble solids and the drying ratio, representative of a wide range of vineyard plots. The regression equation derived from this study can also be used to predict the drying ratio for a range of soluble solids levels. This is given in Table 26.1. It shows the predicted drying ratio in 0.5 °Brix increments of soluble solids, including the expected raisin yield from 9 tons of fresh grapes at each maturity level. This information is particularly useful in determining the economics and returns for making raisins as compared to selling 'Thompson Seedless' grapes on a fresh weight basis to a dehydrator or winery. It also demonstrates the gain in raisin yield that would be realized if harvest were delayed 1 week for a potential increase in fruit soluble solids of 1 to 1.5 °Brix.

Harvest costs. The higher yield from higher-maturity fruit affects harvest costs as well as gross returns per acre. Because of the more favorable drying ratios, raisin tray weights increase with grape maturity. In other words, it takes fewer trays to make 1 ton of raisins from high-sugar grapes than from low-sugar grapes. This is illustrated in Table 26.2. Since fewer trays are required, harvesting costs decrease. This includes picking, turning, rolling, and boxing labor. Bin costs are reduced as well, since higher-maturity fruit require fewer bins per ton of raisins.

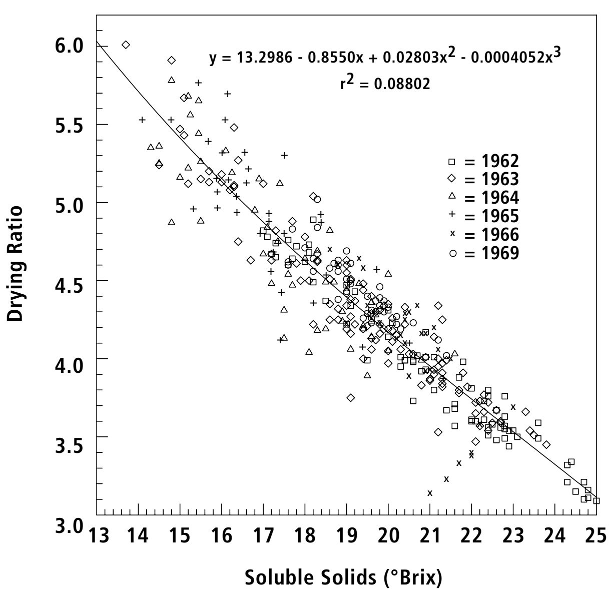

Figure 26.2 Effects of soluble solids on drying ratio, Fresno and Madera Counties

Table 26.1 The predicted drying ratios and raisin yields for a range of soluble solids levels*

Grape soluble solids	Dry ratio *(fresh weight : dry weight)*	Raisin yield *(tons of raisins from 9 tons fresh grapes)*
15 °Brix	5.42 : 1	1.66
15.5 °Brix	5.27 : 1	1.71
16 °Brix	5.14 : 1	1.75
16.5 °Brix	5.00 : 1	1.80
17 °Brix	4.87 : 1	1.85
17.5 °Brix	4.75 : 1	1.89
18 °Brix	4.63 : 1	1.94
18.5 °Brix	4.51 : 1	2.00
19 °Brix	4.39 : 1	2.05
19.5 °Brix	4.28 : 1	2.10
20 °Brix	4.17 : 1	2.16
20.5 °Brix	4.06 : 1	2.22
21 °Brix	3.96 : 1	2.27
21.5 °Brix	3.85 : 1	2.33
22 °Brix	3.74 : 1	2.41
22.5 °Brix	3.64 : 1	2.47
23 °Brix	3.54 : 1	2.54

*Values are based on the regression equation derived from field trials as shown in Figure 26.1 and a fresh yield of 9 tons per acre.

Table 26.2 The influence of grape maturity on harvest costs*

Grape soluble solids	Raisin tray weight from 20 lb of grapes	Number of trays per ton of raisins†-
16 °Brix	3.89 lb	514
17 °Brix	4.11 lb	487
18 °Brix	4.32 lb	463
19 °Brix	4.56 lb	439
20 °Brix	4.80 lb	417
21 °Brix	5.05 lb	396
22 °Brix	5.35 lb	374

*Weight of dried raisins per tray and the number of 20-pound (9.07 kg) fresh weight trays needed to yield 1 ton of raisins at various grape maturities.

†-To convert to the number of 9.07 kg fresh trays per metric ton, multiply by 1.103.

Quality

Higher-maturity fruit produces higher-quality raisins as well as higher raisin yields. Thus, raisin quality considerations should also influence the time of harvest. Generally, high-quality (high-maturity) raisins are plump, meaty, and fine wrinkled, the result of having harvested grapes at a high soluble solids content.

Raisin quality standards for maturity are based on airstream sorter machine grading. This grading method separates raisins based on their ability to drop in a column of air at a calibrated pressure differential. The heavier, finer-wrinkled raisins of higher quality tend to drop in the column and thus receive the higher A and B grades. The poorer quality, lighter-weight raisins will tend to lift and be blown over in the airstream and fall into either C or Substandard grade. The proportion of raisins falling into A and B grades (called *B and better*) generally goes up when the raisins are produced from grapes of higher soluble solids content. A more detailed discussion on raisin grades and standards and the airstream sorter is given in chapter 30, Raisin Quality, and chapter 31, Quality Standards and Inspection.

The influence of grape maturation on raisin quality can be demonstrated from the results of a time-of-harvest study conducted in a Fresno County 'Thompson Seedless' raisin vineyard over three growing seasons. Researchers found that for every week that harvest was delayed, the B and better grades increased by an average of 11.5 percent. This was during a 3-week period from the third week in August to the second week of September when B and better grades went from 45.5 percent to 80 percent. At the same time, fruit soluble solids were increasing by 1.1 °Brix and raisin yields were increasing by 457 pounds per acre (512 kg/ha) per week. These results reaffirm how raisin yield and quality are both closely tied to fruit soluble solids at harvest.

Raisins must meet minimum maturity grade standards for the packer's incoming inspection. Also, some raisin packers pay a premium for higher B and better raisin grades, a further incentive for growers to harvest grapes at a higher degree of maturity. As a general rule, grapes should have average soluble solids readings of at least 19 °Brix in order meet minimum incoming grade standards. Information on predicting raisin grades based on fresh fruit characteristics is detailed in chapter 30, Raisin Quality.

Rain Risk

The date of raisin harvest is strongly influenced by calendar date well as fruit maturity. This is because the decision to let the grapes reach a higher maturity must often be weighed against cooler, poorer drying weather and an increased risk of rainfall. In the San Joaquin Valley, September 1 is a common target date for harvest to begin; September 15 is the latest date most harvests are completed. Industrywide, September 20 is the latest date to consider harvest completion; it is also the last harvest date for which rain insurance policies will provide coverage.

These harvest guidelines are based on historical weather records and grower experience of rainfall during harvest. Rainfall records have been recorded for Fresno by the National Weather Service and its predecessors since 1887. These records are graphed for 107 years through 1993 in Figure 26.3 to show the daily incidence and severity of rainfall from September 1 to October 15.

The top graph (≥0.75 inch) includes the rainfall periods that would be considered potentially devastating to a raisin crop. They have occurred 10 times over 107 years, all but once at scattered times beginning in late September. The notable exception was on September 4, 1978, when 0.92 inch (2.3 cm) of rainfall was recorded in Fresno. These heavy rains can be expected to cause significant damage even when followed by good drying conditions. This is largely because of the subsequent presence of moisture in the soil, especially underneath the trays.

The second graph (0.25 to 0.74 inch) includes rainfall amounts that, although potentially very damaging, allow a chance to save some if not all of the raisins. The rainfall incidence is relatively infrequent through September, increases noticeably about October 1, and then remains somewhat constant through October 15. The degree of raisin damage in this rainfall category would depend on weather conditions after the rain as well as the actual rainfall amount. For example, cloudy days following the rain would greatly enhance mold damage, even with only 0.25 inch (0.6 cm) of rain. Conversely, 0.50 inch (1.3 cm) of rainfall with sunny, hot, windy weather may result in only minor mold problems.

The third graph (0.01 to 0.24 inch) includes rain-

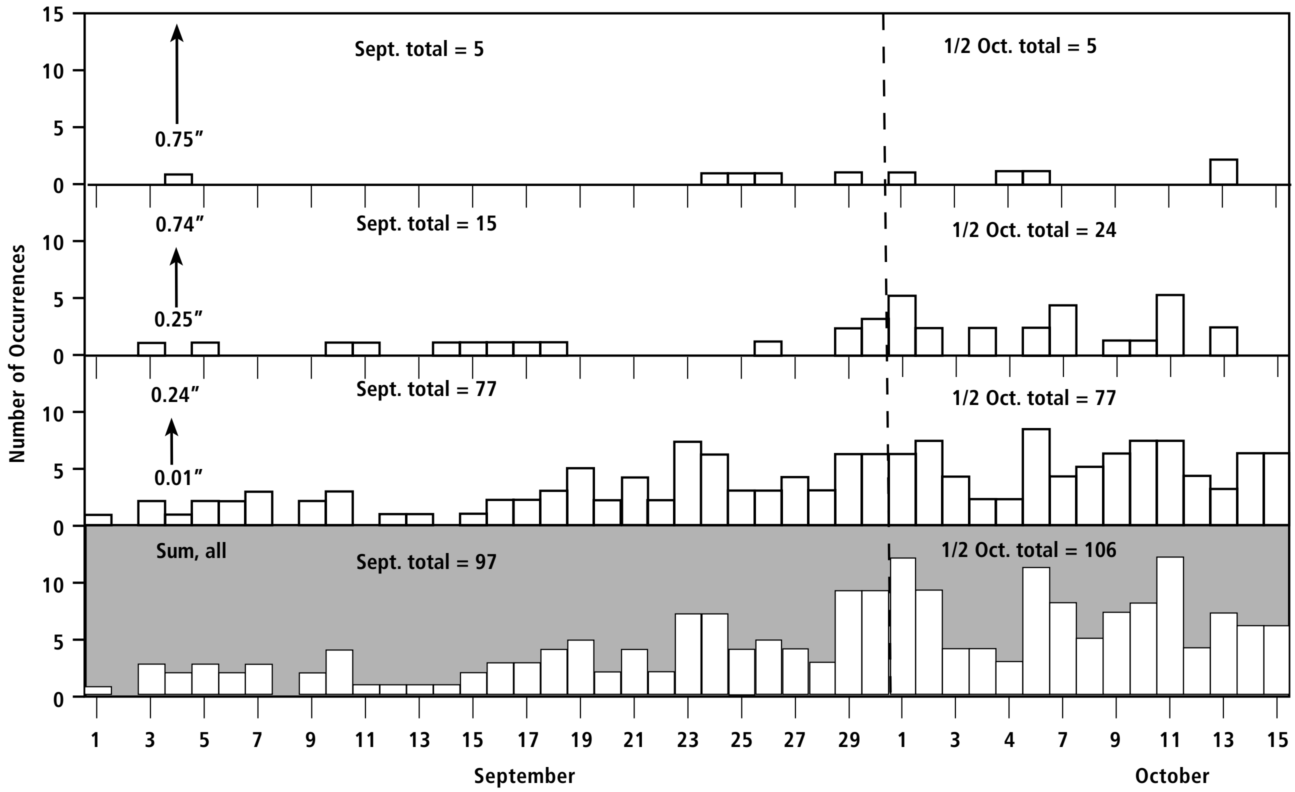

Figure 26.3 Rainfall amounts by number of occurrences, 1887 to 1993. The four graphs illustrate the amount of rainfall in storms as well as their frequency on a daily basis. The top graph shows the frequency of rains of 0.75 inch (1.9 cm) and greater over the years of record. The frequency of rains of lesser amounts are shown below in stepwise graphs. The bottom graph shows the cumulative data from the other three graphs and includes all of the recorded rain occurrences.

fall amounts that would cause only minor problems, if any. Incidence increases in late September and remains fairly constant through October 15. Extensive problems would only be expected if weather conditions continued to be cloudy or rainy for several days or with poor terrace preparation or damaged fruit.

The fourth graph is the sum of all categories. It indicates some overall increase during the third and fourth weeks of September. However, most of these increases are in the 0.01-to-0.24-inch category. Rainfall patterns increase again toward early October, but with an increased proportion in the 0.25-to-0.75-inch category. Thus, most of the higher rainfall amounts occur during October, except for infrequent and sporadic events. These records confirm the need to complete harvest by mid-September to minimize the risk of crop loss to rainfall damage.

The type or origin of a storm influences the amount of rainfall as well as the subsequent drying conditions. Most typically, cold front storms move into the San Joaquin Valley from the northwest with showers and sometimes thundershowers. They usually result in less than 0.25 inch of rain and move out of the area in a day or two. They are most often followed by cool, dry winds and a warming trend. They are the least damaging storms because of their relative short duration and the increasingly favorable drying conditions that often follow in a day or two.

In contrast, tropical storms during the drying season typically dissipate south to southwest of southern California and feed moisture rapidly northward. They can drop more than an inch of rain, and drying conditions can often remain poor for a week afterward due to lingering clouds and high humidity. The warmer temperatures of these storms also encourage fruit decay. The severe industry losses of 1976, 1978, and 1982 were the results of tropical storms.

Availability of Labor

Industry sources estimate that as many as 55,000 workers are needed during the 6-week raisin harvest period. Thus we can expect some harvest schedules to be accelerated or delayed because of harvest crew availability. The data in Table 26.3 give a breakdown of this labor requirement according to operation. Picking accounts for about 53 percent of the total labor hours needed and makes up a large part of the peak number given above. This example is based on an average hourly picking rate of 30 trays per worker from a 1965 study on the performance of 394 individual workers. The picking rates ranged from 19 to 57 trays per hour, depending on picking conditions and individual picker productivity. Opportunities to reduce this labor requirement are very limited until growers adopt more mechanization methods. In the meantime, some labor needs have been reduced by eliminating the turning operation and using mechanical pickup equipment for boxing.

Other Considerations in Harvest Scheduling

Vineyards with a north-south row orientation usually are harvested earlier than those with an east-west orientation. This is because the morning and afternoon shading by vine canopies causes grapes to take longer to dry in north-south rows. Fruit drying in north-south rows will have only 5 to 6 hours of direct sunlight each day in early September; east-west rows will have about 12 hours. Typically, it takes 7 to 10 days longer to dry in north-south rows. This has prompted many growers to target September 1 as the completion date to harvest north-south rows. Vineyards with large trellises such as those used for table grapes may also require an earlier harvest date to minimize canopy shading during drying.

Sampling Grapes for Maturity

The best way to set the picking date is to harvest raisin grapes based on soluble solids content as indicated by a representative field sample. However, you may be misled by improperly collected samples that give a false reading of fruit maturity. It is important that you use the proper procedures for berry sampling.

Sampling method. Research on different sampling methods has shown the advantages and disadvantages of sampling whole vines, clusters, or berries. Whole-vine samples provide readings that accurately represent the vine's entire crop. Vine-to-vine variability is quite high, however, and crushing all of a vine's fruit is impractical and destructive. Cluster sampling has been shown to do the best job of representing true maturity in small plots. This involves taking at least 20 clusters at random and crushing them together—also a large task.

For practical purposes, berry sampling is the best option for growers. When done properly it can provide as representative a sample as the other methods. The key is to obtain a sample that reflects variations within the vine and the field. Individual berries' maturity tends to vary with their location on a cluster. The ripest berries are on the top and shoulders and the least ripe are at the bottom, while the berries in the center of the cluster are at various intermediate degrees of ripeness. Thus, you can use either of two techniques in selecting berries: you can select individual berries, alternating between the top, middle, and bottom of the cluster; or you can select only berries from the middle of the cluster. Studies have shown no differences in the results drawn from these two methods. The key is to avoid taking all of your sampled berries from the top and shoulder, since these will give you a higher soluble solids reading than is accurate for the vineyard as a whole.

Another source of variation comes from the vine itself. You must sample berries from all parts of the vine, recognizing that maturity will vary with cluster location. Select approximately equal numbers of berries from clusters on both sides of the vine, high and low positions, sunny and shady areas, and varying distances from the trunk.

Finally, conditions unique to the individual vineyard can cause variations, particularly conditions associated with soil and irrigation patterns. Usually, harvesting is completed by block and for entire rows. Sampling typically involves walking the full length of several row middles within a block and taking berries from the sunny and shady sides of the rows on either side. This ensures that different soil types such as sand streaks are represented in the sample. Above all, avoid sampling only vines toward the end of rows, as they will not give a true picture of the block's maturity. Each block should be sampled separately, particularly if there are differences in soil type or vine vigor. This will enable you to schedule each block's harvest by its stage of maturity.

Taking the sugar reading. You will not get an accurate indication of field maturity by squeezing single berries onto the refractometer. A convenient alternative is to collect 150 to 200 berries in a plastic bag, crush the contents with your hand, and then pour off the juice onto a refractometer. A kitchen blender does a more thorough job of juicing the sample. You can separate the juice from the macerated fruit by straining

Table 26.3 Typical labor inputs for raisin harvest

Operation	Hours per ton of raisins
Terracing and pulling back	0.75
Picking (30 trays/hour and 450 trays/ton)	15.00
Turning and rolling	7.50
Boxing and shaking	4.75
Hauling to processor	0.15
Total	**28.15**

it through a cloth or several paper towels. Allow the juice to clear before you take a reading.

Take several refractometer readings on each sample to check methodology. Wipe the glass prism with a damp cloth and then dry it with a clean cloth between readings. Unless you use a temperature-compensating refractometer, it is important that you follow instructions on adjusting your readings to compensate for temperature differences. Temperature-compensating refractometers automatically adjust their readings to allow for temperature differences. When using a non–temperature-compensating refractometer, it is best to take readings at room temperature (70° to 78°F [21° to 25.5°C]) to avoid outside extremes.

The refractometer measures soluble solids in degrees Brix (°Brix). The °Brix scale is based on the refractive index of fruit soluble solids. It measures the refraction of light rays as they pass from one medium to another of different density, in which their velocity is different. It very closely represents the percentage of grape sugars by weight and thus is commonly expressed as percent soluble solids or sugar.

Titration for grape acid need not be considered in maturity testing for raisin grapes. It does not represent maturity effects on raisin yield and is a much poorer indicator of airstream sorter raisin grades than are soluble solids (°Brix) readings. See chapter 30, Raisin Quality, for more information on °Brix and grape acid relationships to raisin grades.

PREPARATION FOR HARVEST

Cane Trimming

You only need to trim canes in vigorous vineyards where the bottom of the vine canopy may interfere with terracing and raisin drying. It involves trimming the shoots that are trailing down from the trellised canopy back to 12 to 24 inches from the vineyard floor. This is a common practice in T-trellised vineyards, where it allows the terrace and the trays to be placed closer to the north side of the vine row, ensuring a wider area of unshaded surface.

Soil Terracing

When growers terrace the soil, they slope, smooth, and firm the soil on which the trays will rest. Soil terracing is an important element in optimizing drying conditions and minimizing the potential for rain damage. Several types of equipment are used; advantages and disadvantages for each are described below.

Guidelines to Terrace Preparation

Soil dry and free of trash and clods. Cover crops or weeds in the row middles should not be allowed to become dense or fibrous after July 1. The soil should be disked prior to the last irrigation if weedy growth is present. This incorporates the vegetation so it will decompose in moist soil. Final soil preparation after the last irrigation usually takes at least two cultivations to loosen the soil and break up clods. Typically, one disking and one spring-toothing are needed in sandy soils; two diskings plus spring-toothing is the most common combination in medium- to fine-textured soils.

Soil dryness will depend on the soil texture and the timing of the final irrigation. Vineyards on sandy soil can often be cultivated and terraced within 2 weeks after irrigation; medium- to fine-textured soils usually require 3 to 4 weeks between irrigation and final soil preparation.

Drip-irrigated vineyards may have some wetted or weedy areas that require soil tillage practices similar to those used for furrow-irrigated vineyards prior to terracing. Otherwise, only one pre-disking may be required, as the centers will already be dry.

Make up the terrace as close to harvest as possible to minimize tracks in the surface. You may need to terrace 4 or 5 days ahead of picking, however, if the subsurface soil is still damp, especially in fine-textured soils. This will allow time for the newly exposed terrace surface to dry before harvest.

Terrace smooth, firm, and properly sloped. The smoothness of the terrace depends on good soil preparation: the soil should be dry, loose, and free of clods and trash. The blade or ridger that moves the soil should be followed with a weighted drag or roller. This firms the soil to minimize footprints and other depressions that would otherwise create pockets where the trays could collect rainwater.

By sloping the terrace to the south in east-west rows, you expose the grapes more directly to the sun's rays to hasten drying. This also provides for drainage in case of rain. The amount of slope depends upon the rain risk, grower preference, and type of terracing equipment. Most typically, growers will use slopes of 1 to 2 inches per foot (8.3 to 16.7 cm/m), a slope of about 8 to 17 percent. Early harvested vineyards may have less of a slope, while late-harvested vineyards may use slopes even greater than 17 percent. The terrace should be placed toward the north side of the row middle, especially where T trellises or late harvests cause more shading. It may also be necessary to mechanically trim the bottom of the vine canopy so the terrace can be placed even further northward to avoid shading of the trays. Drainage outlets should be provided at the ends of the rows where water would be expected to collect in the event of a heavy rainfall.

Sloping is not necessary for north-south rows—only leveling and smoothing. However, a terrace sloped 5 to 10 percent to the west will help drain possible rainwater.

The soil surface need not be especially well firmed or compacted. Some growers even prefer a slightly fluffed or textured surface to provide for some air exchange under the trays. This may minimize the spreading of moisture underneath a non-poly tray.

Selection of terracing equipment. A *single-slope* or *sled terrace* (Figure 26.4) is most common; it is made with a curved blade pulled at a slant to move the soil upward.

Advantages:

- Steepness of slope.
- Fruit are placed closer to the north side of the vine yard row.
- Can accommodate large crops that require extra tray spaces.

Disadvantages:

- Rainfall from the vine canopy may run onto the terrace.
- Pickers in the adjoining row may disturb the terrace or kick soil onto the trays.

A *raised-bed* or *Vaughn terrace* (Figure 26.5) is a more recent design. It makes an elevated, sloped plateau or bed in the center of the row with "dead" furrows on each side.

Advantages:

- Rainwater from the vine canopy falls into the terrace furrows, and not onto the terrace area.
- A tractor can straddle the trays if sprays (such as potassium sorbate or SOT [sprayed-on-the-tray] drying emulsion) are to be applied to the trays.

Disadvantages:

- Preparation of a Vaughn terrace requires an abundance of loose soil.
- Shading can be a problem on the south end of the trays.

The *V terrace* (Figure 26.6) is another nontraditional design coming into increasing use. The soil is sloped up from the middle toward both sides of the vine row so the lowest spot is in the middle of the row, with equal amounts of soil sloped up on each side.

Advantages:

- Less soil has to be moved to form the terrace.
- Postharvest irrigation can be applied without reforming the row middles.
- The terraced area can be leveled out with one tan-

Figure 26.4 A properly sloped, wide sled terrace provides good water drainage. Note that canes have been trimmed to avoid shading. *Photo: L. Peter Christensen.*

Figure 26.5 Raised-bed or Vaughn terrace provides drainage on both sides of the canopy and allows equipment access directly over trays. *Photo: Jack Kelly Clark.*

Figure 26.6 The V terrace is easy to re-level after harvest.
Photo: L. Peter Christensen.

dem disking operation.

Disadvantage:

- The terraces are somewhat limited in width.

Tray Selection

The drying trays used for sun-dried raisins have changed significantly over the years. In the early days, wooden trays were the standard. These worked well, but maintenance was expensive and storage, spreading, and retrieval were labor intensive. Traditionally, paper trays measured 24 by 36 inches (0.6 by 0.9 m) of either regular or wet strength kraft paper. Changing farming practices, weather-related crop failures, and individual ingenuity have stimulated continued development in paper tray technology. Many new paper trays have been developed; individual growers can choose from among several options to find the best tray for their vineyards.

- *Regular paper,* a strong blend of wood pulp fibers with a high sizing level. ("Sizing" is the degree to which the paper tray resists water penetration). Regular trays perform very well in normal drying conditions. They resist water, allow the tray to breathe, and are strong—unless they get too much moisture. They do not retain tensile strength when wet, and will tear.

- *Wet-strength paper,* produced from the same strong wood pulp fibers with high sizing, but with an additional ingredient: wet-strength resin. This material attaches to the wood fiber and helps the paper retain much of its strength even after it gets wet. Wet-strength paper provides added protection in the event of rain or excessive dew and allows more handling of the wet tray.

- *Poly-coated paper,* wet-strength paper with a thin layer of polyethylene (approximately 5 pounds per ream of 3,000 square feet [8.2 kg/1,000 m^2]) extrusion-coated onto one side. These trays are laid polyethylene side down to provide a moisture barrier between the fruit and the soil. Poly-coated trays can be rolled to provide a shelter from the rain as the paper sheds water and acts as a "raincoat." Because poly-coated paper is such a good barrier, it has the disadvantage that it holds moisture inside a rolled tray, restricting complete drying, especially with biscuit-rolled trays. Thus, the fruit on poly-coated trays must be more evenly dried and more fully cured before rolling. Pockets of uncured, high-moisture fruit have been known to become moldy or begin fermenting in biscuit rolls. Only cigarette rolls or flop rolls should be used with poly-coated trays. Clusters that already contain rot when they are placed on the trays at harvest are also more of a problem with poly-coated paper. The rot tends to spread and run down the trays because of the poly barrier. In contrast, non–poly-coated trays tend to act as blotters and transfer the wetness toward the soil underneath the tray.

  The moisture barrier of poly-coated paper can effect the rate of drying both ways. It has a slight slowing effect under normal drying conditions, but it helps drying if there is moisture underneath the trays. Poly-coated trays are also available with or without vents. Vented trays are punctured with evenly spaced holes that provide water drainage through open trays and to allow moisture vapor to escape from rolled trays. They were developed as a way to minimize the problems associated with the high moisture barrier.

- *Surface-sized,* a wet-strength paper that is saturated with a waxlike surface sizing material to produce a highly water-resistant paper that also has the ability to breathe. Surface-sized trays do not provide as permanent a moisture barrier as poly-coated trays. This means they do not shed water as long as poly-coated trays do, but they allow the fruit to continue to dry after rolling. If there is no rain, surface-sized trays act just like wet-strength trays and do not retarding drying at all.

Many growers like to have either poly-coated or surface-sized trays on hand. In case of rain they can transfer the fruit from wet-strength trays to water-shedding trays. This can be accomplished by turning or slipping the raisins onto the premium tray, which will provide a moisture barrier against the wetted soil. As an alternative, two or three cigarette or flop rolls can be placed onto individual poly-coated trays to help them dry on wet soil. Many growers consider that the greater protection provided by premium trays easily offsets their added cost.

Tray dimensions. The traditional dimensions for paper trays have been 24¼ × 36 inches, and this was standard for many years. Growers with high trellises or narrow rows have had some success with square trays (30 × 30 inches) due to shading problems. This is because the fruit is confined to a strip 6 inches narrower in the row middle. A compromise is the extra-wide tray (26 × 34½ inches or 27 × 33 inches).

Continuous tray. One result of the development of mechanical harvest devices is the continuous tray, which consists of tray material wound into rolls of specified widths. The continuous paper (Figure 26.7) is typically of a heavier weight (50-pound basis weight [equivalent to 50 pounds per ream of 3,000 square feet]) than individual trays, which run from 37 to 40 pounds basis weight. Continuous paper is also manufactured as extensible material so that it will stretch (typically a 5 percent stretch factor) and contract under the temperature extremes in the field. Most other kraft papers tend to tear, break, or curl under field and handling conditions.

Continuous paper is available in a variety of widths ranging from 30 to 40 inches. The width selection will depend on your equipment specifications and your anticipated crop size. Widths of 32 to 34 inches are most common for hand harvest; a wider tray of 38 to 40 inches is used with a machine harvester in order to avoid stacking more than two layers of single berries.

Figure 26.7 A continuous tray on a raised bed terrace.
Photo: Jack Kelly Clark.

Picking and Spreading

A round picking pan and a curved-blade knife are the most traditional picking tools. The pan has an outer lip for handling and should hold 20 to 22 pounds (9.1 to 10 kg) of fruit. Some growers have used a wooden tray carrier in place of a pan because it permits the fruit to be picked directly onto the tray, which is then slipped off onto the terrace when filled. While this method reduces fruit spillage and breakage, it is more awkward to use and more expensive to replace than the traditional picking pan.

A good picking job requires a lot of supervision. Pickers vary in their skill and attention to the task; common problems include fruit that is missed on the vine, spilled on the ground, crushed, or unevenly spread on the trays. New pickers will need instruction and experienced ones may need to be reminded to do the following:

- Place the pan directly under the fruit to be picked to catch loose clusters or berries.
- Use a knife to cut clusters from the vine and to cut tangled clusters in half. Do not jerk or strip the clusters off.
- Keep rot off of the tray by avoiding clusters with rot or cutting the rotten portion out.
- Avoid cutting or crushing berries. The juice accumulates soil, attracts vinegar flies and dried fruit beetles, and may initiate rot.
- Spread the fruit evenly on the trays, being careful not to mash the berries; remove all leaves and refuse (Figure 26.8). Keep loose berries from rolling off of the bottom end of the tray by placing several clusters along the bottom before spreading.
- Keep the trays uniform in weight for even drying. Do not overload trays, since that will slow drying and increase the potential for rot, especially in the event of rain. Trays of 20 to 22 pounds (9.1 to 10 kg) are a common goal for optimum or maximum

weight. Lighter trays increase the costs of harvest but result in faster drying and less need to turn.

- Very large clusters may dry better if cut into smaller ones. However, you should avoid this practice if the clusters are so tight that you cannot avoid cutting or crushing berries.

- Keep foot traffic out of the drying area.

- Do not kick sand onto the drying trays.

- Place the trays far enough north on the terrace to minimize shading.

Turning, Rolling, and Boxing

Only the basic aspects of turning, rolling, and boxing will be outlined here. More detail on the drying and curing process is included in chapter 27, The Raisin Drying Process.

Turning. In many cases turning is not an essential operation: probably fewer that 50 percent of raisin trays are turned. Turning is a necessity in the following situations: with clusters that are too large to avoid the inclusion of an excessive amount of green, undried berries; with late harvests or slow drying conditions such as cool weather or north-south rows; with heavy trays or trays in which some rot is progressing in the bottom-most fruit; or after a rain (Figure 26.9). Many growers still prefer to turn raisins in order to hasten the process of getting the evenly cured fruit boxed, run over the shaker, and delivered.

Turning is normally timed to occur when the berries on the top layer are brown and shriveled. This can occur after 7 to 10 days of hot weather [100°F (28 °C) and above] or after 10 to 14 days of normal drying weather (low to mid 90s). The turning exposes green and uncured berries from underneath to complete the drying.

Rolling. The rolling operation greatly slows the drying process, protects the fruit from over-drying or caramelization, provides rain protection, and facilitates raisin pickup and boxing.

Timing for rolling is mostly based on experience and judgment of raisins' moisture content. The decision can be difficult even for experienced growers due to seasonal differences in fruit characteristics, drying conditions, and pickers. You will need to examine enough representative trays daily to follow the progress of differences among individual trays, rows, soil types, and pickers, as well as harvest date. You must keep in mind that the fruit to be rolled will be a blend of over- to under-dried raisins that will continue to cure and equalize their moisture in the rolls and bins.

When judging raisin moisture, you have to take fruit temperature into consideration. This is because very warm fruit in the afternoon will be very pliable, and will feel like high-moisture fruit. The same fruit in the cool morning will be firm as if it were of lower moisture. It is usually best to check drying raisins at midmorning when they are closer to an average ambient temperature. Less-experienced growers may wish to have their packer run a moisture analysis on a few trays to get an idea of moisture content based on appearance and feel.

The first few trays at the row ends typically do not dry as quickly as the other trays in the row. This is probably because temperatures at soil level are cooler at the vineyard edge than farther down the row where heat accumulates because of reduced air circulation between the canopies. Thus, you should avoid the first few end trays when judging raisin moisture for a field.

Figure 26.8 Removing leaves from an evenly spread tray of grapes. *Photo: L. Peter Christensen.*

Figure 26.9 Turning trays to prevent any berries from remaining uncured and to hasten drying. *Photo: L. Peter Christensen.*

Timing for rolling will also depend on current drying conditions and the type of roll to be used. If drying temperatures are high (95°F [35°C] or above), it is best to roll the raisins more on the "heavy" (higher-moisture) side. This is because further delay may cause overdrying and caramelization; continued drying and curing can then proceed at a safer, slower rate in the roll. Also, if you use a more open, ventilated roll such as a cigarette or flop roll, you can roll the raisins at a higher moisture content than if you use a biscuit roll.

You must be particularly careful about overdrying 'Fiesta' or 'Zante Currant' raisins, especially during hot weather. Once dry, their fruit caramelize more easily than 'Thompson Seedless' fruit. Caramelization can be indicated by raisins that are turning reddish black rather than the normal, brownish purple color. The fruit will have a caramelized or burnt sugar taste. Caramelization will occur first in raisins that are already dry, completely exposed to the sun, and lying directly on the tray. With 'Fiesta,' caramelization can result in black, puffed-up, round raisins that have a very burnt flavor. Thus, with the typically higher drying temperatures for early harvested 'Fiesta' and 'Zante Currant,' it is best to roll them on the heavy side and let them finish drying in the roll.

The type of roll you use will depend a lot on your own preference and experience; it may be influenced by the fruit moisture content, the amount of curing needed, and the amount of protection desired. *Biscuit rolls* (Figure 26.10) offer the most protection and the slowest drying time; they are compact and have no open ends for exposure, so the timing of boxing after rolling is not very critical. The drying of heavy clusters in a biscuit roll can be facilitated by shifting those clusters during rolling so they will end up in the top of the roll. This part of the roll will get warmer during the day and that will hasten the drying of the top fruit. This roll should not be used with poly-coated trays, since water vapor from high-moisture fruit will be unable to escape.

Cigarette rolls (Figure 26.11) are easier to shake out during boxing but do not offer as much protection from weather as biscuit rolls. The fruit can have a higher moisture content when rolled since the cigarette roll offers greater ventilation for continued drying. The rolls are commonly used with mechanical pickup systems because it makes the raisins easy to retrieve and separate from the tray. Cigarette rolls are often preferred as a temporary protection from the threat of rain. The rolling operation is quicker than biscuit rolling and the trays can easily be reopened to complete the drying.

Flop rolls (Figure 26.12) are sometimes referred to as the *Biola Flop* due to claims that they originated in that district. They are the easiest rolls to make and to shake out when boxing. They provide the least rain protection, but allow for continued drying in the roll. They are often used when the trays are not turned, as high moisture fruit will continue to dry most quickly in this roll. The inclusion of a few uncured berries is usually not a problem because the flop rolls allow continued drying.

Boxing. Raisins usually are boxed after they have cured adequately and equalized their moisture in the rolls. Sometimes the decision to box is dictated by weather conditions.

Raisins must be at 16 percent or less moisture content to meet the industry's incoming inspection requirements. Obviously, higher-moisture raisins make for a higher deliverable tonnage. However, there is a sliding payment adjustment between 10 and 16 percent moisture that partially compensates growers for delivering lower-moisture raisins. This compensation reduces the grower's incentive to deliver raisins at as high a moisture content as possible.

Most growers rely on their experience to judge raisin moisture content at the time of boxing. For those who wish to have a laboratory run a raisin moisture

Figure 26.10 Biscuit roll. *Photo: Jack Kelly Clark.*

Figure 26.11 Cigarette rolls. *Photo: L. Peter Christensen.*

Figure 26.12 Flop rolls. *Photo: Jack Kelly Clark.*

analysis before boxing, the most important consideration is that the grower get a representative sample. This is not an easy task, as only about ½ pound of raisins is actually used in the moisture tester. We suggest the following sampling method. It results in a sample of about 2 pounds to represent each block to be tested.

All of the fruit from a minimum of 10 trays should be in the sample. Each tray should be taken from a different row and a different tray number within the row (e.g., tray number 10 in the fourth row, tray 20 in the eighth row, tray 30 in the twelfth row, etc.). You should not be influenced by tray appearance and should pick the designated tray number regardless of whether it looks heavy or light. You can collect the raisins in a 5-gallon bucket and then dump them into a larger container such as a clean 35-gallon trash can. This will give a 45- to 50-pound sample, which will now need to be thoroughly mixed. First, divide it into several large containers (35-gallon trash cans work well), mixing by hand, and then blend it back into a single container. Do this two or three times to ensure a good blend. Finally, split the 50 pounds of raisins back into three containers and grab two or three handfuls of raisin from different locations in each. Mix them and pour them into a zip-sealing plastic bag. This will give you about 2 pounds of raisins that you can take to the packer for testing.

Growers use a wide variety of boxing methods depending on their own preferences, vineyard size, availability of equipment, and desire to mechanize. For *yard boxing,* you collect and haul in biscuit rolls on a flatbed trailer and then dump them into containers or onto a shaker in the farmyard. This method provides an opportunity to sort through the raisins as you dump the trays. However, this once-common practice is seldom used today due to its slower pace and higher labor input as compared to field boxing.

Field boxing is the hand or mechanical pickup of raisin rolls and separation of raisins from the tray directly into a container. The picking up is most commonly performed by workers walking alongside the trailer. Some growers have designed removable seats that attach to the frame of the bin trailer where the workers can ride while they pick up trays. This places the workers in a low sitting position where they can grab and toss biscuit rolls into the bins without bending over. The seats can be moved to alternate sides of the trailer depending on the side of the row on which the trays have been placed.

Mechanized raisin roll pick up was begun in 1954 by a Fowler area raisin grower. Since then, numerous growers and equipment manufacturers have designed and built machines that pick up raisin rolls, separate the raisins from the trays, burn the discarded trays, and in some cases screen the raisins in the field. Most equipment, however, only picks up the trays and conveys them to workers who separate them from the raisins by hand. The pickup device uses metal prongs to reach underneath the trays and move them onto a conveyor belt with the assistance of overhead paddles or a draper chain mechanism. Such a pickup machine will reduce the labor requirement by about one-third; a machine-assisted crew of three workers will typically do the work of five people picking up by hand. Proper soil preparation to avoid a cloddy soil on the terrace is very important with mechanical pickup. Otherwise, the machines can retrieve clods along with the raisin trays.

The bulk bin has largely replaced the sweat box. This change has helped to speed up boxing and facilitate the use of mechanical aids and handling with bin trailers, forklifts, and bin dumpers. Most growers pick up directly into bulk bins, although some use other bulk handling methods such as metal tipster bins, wine grape gondolas, or modified manure-type spreaders. An advantage of picking up directly into bins is that they will provide immediate storage capacity for the entire crop. With other containers, the raisins are usually shaken as they are picked up and then placed into bins. This added step limits the rate of the picking up, and that can be a problem with rainy weather.

Bulk bins will typically hold 1,000 to 1,050 pounds (454 to 476 kg) of raisins before shaking. After shaking, they will hold about 10 percent more weight, or 1,100 to 1,150 pounds (499 to 522 kg) of raisins. Sweat boxes hold about 150 and 165 pounds (65 to 75 kg) of raisins before and after shaking, respectively.

HANDLING AFTER BOXING

Screen Shaking

Most growers screen-shake the raisins on the farm before delivery; it is a requirement of some packers. The advantages of this practice are several:

- Sand, chaff, insects, sandburs, feathers, mold, and other foreign materials are removed.
- Raisins of varying moisture contents and grades can be blended together.
- The grower can closely monitor the condition and quality of raisins coming out of different blocks.

Screen material with a mesh size of 3⁄16 to 7⁄32 inch (0.48 to 0.55 cm) is standard for 'Thompson Seedless' and similar varieties. Some growers will use 1⁄4-inch (0.64 cm) mesh screens in order to remove some substandard raisins from varieties such as 'Thompson Seedless.' This can be useful if most of the very small raisins are of substandard quality. However, one must judge whether the larger-mesh screen is removing a disproportionate amount of midget-sized raisins that would meet grade. If so, the amount of crop loss may not justify the possible improvement in airstream sorter grade.

'Zante Currant' raisins require a fine-mesh screen of 1⁄16 to 3⁄32 inch (0.16 to 0.24 cm) mesh. Some growers just use window screen material and tie it down with wire onto an existing standard mesh screen.

Various attachments for shakers are available for reconditioning or blending raisins. A coarse scalping screen can be used to remove clumps of moldy or sticky raisins. Vacuum or blower attachments will remove light or substandard raisins. These attachments are positioned at a drop point or on the discharge end of the shaker to remove poorly developed raisins from the falling column (Figure 26.13). They can also help by removing feathers and sandburs. Most packers and commercial reconditioners have specialized equipment available to recondition for various defect and grade problems.

The blending of raisins such as those with differing moisture contents is best accomplished by using two bin dumpers simultaneously. The raisins can be dumped onto two separate shakers and blended into a common bin. Another method is to empty bins with two dumpers onto belts that convey the raisins to a single shaker for blending.

Before shaking raisins, allow enough time for the raisins to equalize their moisture content. This will reduce the possibility of breakage and sand contamination of soft, high-moisture berries during the shaking operation. Also, to avoid mechanical damage to soft fruit, never run high-moisture (above 18 percent moisture) raisins across a shaker.

On-Farm Storage

Raisins should be delivered to the packer as soon as possible. Prompt delivery assures timely fumigation and protection from insect and rodent infestation. You should only hold raisins on the farm to allow for moisture equalization and delivery scheduling. On-farm fumigation is rarely practiced due to chemical safety issues and the ability of packers to receive raisins

Figure 26.13 A raisin shaker that includes a vacuum attachment on the discharge end to remove light, off-grade raisins.
Photo: Jack Kelly Clark.

quickly and efficiently through improved bulk handling and storage methods.

Protection from weather and rodent infestation are the main concerns with on-farm storage. Storage stacks in the open should be well covered with a gas-tight paper such as Sisal Kraft or polyethylene sheeting. They should be sloped to allow rain runoff and should have air space between the raisins and the top covering. Without this top space or "attic" to prevent direct or close contact between the covering material and the raisins, heat from sunlight during the day can caramelize the top raisins. Growers commonly use boxes or buckets and grape stakes or boards to form a roof over which to drape the covering material. There should be sufficient overlap at the ends of individual rolls of covering material to prevent rainwater from leaking into the stack. With plastic, it is important to pad or remove sharp objects such as splinters, nails, or stems to prevent punctures. A layer of used plastic or Sisal Kraft placed below the waterproof layer on the stack helps protect the top layer from puncturing. Be careful about reusing plastic covering: punctures can be patched with duct tape, but one leak in the top of a stack can soak several bins of raisins. The safest strategy is to use only new plastic for the outer layer of covering.

Temporary storage of 2 weeks or less may only require a cover to halfway down the bottom bin on a stack. For longer-term storage, the cover should extend to the bottom of the stack. There should be enough extra cover at the bottom for it to lap on the soil surface. You can then bank soil onto the lap to make a ground seal that will keep rodents from entering the stack.

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