Chapter 12

Crop Prediction

Crop prediction or estimation is the process of projecting as accurately as possible the quantity of crop that will be harvested. Why estimate the crop? The most obvious reason is to know how much crop will be present for sale or utilization. Beyond that fundamental reason, it is also important to know whether vines are undercropped or overcropped. In the absence of methodical crop estimations, the experienced grower can rely on past vineyard performance. This approach is subject to error, however, especially in grape regions subject to spring frosts or winter injury, which can greatly affect a vineyard's productivity from year to year.

Basic Components of Crop Yield

Crop estimation is based on several pieces of critical information: (1) a good historical record of average cluster weights at harvest; (2) an accurate count of current bearing vines per acre or block; and (3) an accurate determination of the average number of clusters per vine at the time of the crop estimate. Of these variables, average cluster weight is most subject to variation from year to year.

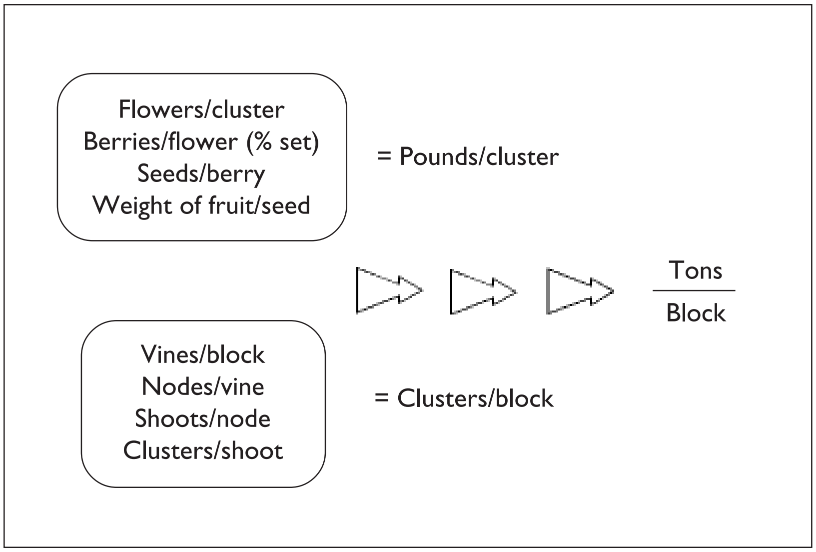
The theory of crop estimation is also based on an understanding of the components of vineyard yield. Those components are shown in Figure 12.1.

As this diagram illustrates, we can differentiate between yield components that contribute to the number of fruit clusters per block and those yield components that determine the average cluster weight. Variability in yield per acre can be traced back to variation in one or more of the many components that collectively determine yield.

Looking specifically at cluster weights (pounds per cluster in the diagram,) it is common to see yearly variation in the percentage of flowers that set fruit. Reductions in set may be due to poor weather during or immediately after bloom, poor vine nutrient condition, and possibly other factors such as pesticide phytotoxicity. Regardless of the cause, average cluster weight data from several years is more meaningful than a single year's data.

The number of clusters per block also varies from year to year. The number of (bearing) vines per block tends to decline through attrition as a vineyard ages unless the vineyardist is conscientious about vine replacement. The number of nodes per vine is a function of dormant pruning severity. The number of shoots per node varies with variety, vine vigor, and the use of shoot thinning as a canopy management practice. The

Figure 12.1. Basic components of crop yield.



number of clusters per shoot is affected by variety, the proportion of bud injury, and the growing conditions of the vine during the previous season. Compared to well-exposed shoots, shoots that develop in dense shade are more likely to have nodes with less fruitful shoots the following year.

Although the relationships shown in Figure 11.1 are helpful in understanding crop variation, it is not essential to consider each component of yield to estimate a crop. In practice, the following equation can be used to estimate crop with reasonable accuracy.

Equation 12.1

$$\text{Estimated Yield (tons/acre)} = \frac{1}{2{,}000\text{ lb}} \times \frac{\text{Vines}}{\text{Acre}} \times \underset{\substack{\uparrow \\ \text{or} \\ \Big[\frac{\text{Clusters}}{\text{Vine}}\Big]}}{\Big[\frac{\text{Shoots}}{\text{Vine}} \times \frac{\text{Cluster}}{\text{Shoot}}\Big]} \times \text{Average Cluster Weight (lb)}$$

As previously stated, the key elements needed to estimate the crop are: (1) the number of bearing vines per acre; (2) the average number of clusters per vine; and (3) average cluster weight at harvest. The 1/2,000 fraction converts pounds (used in expressing average cluster weight) to tons. There are more sophisticated procedures for estimating crop, but this equation provides a reasonably accurate prediction. The following sections present specific recommendations for determining the values of the three critical elements of the equation.

Number of Bearing Vines Per Acre

The maximum number of vines per acre is determined by the row and vine spacing. A full planted acre of vines spaced 8 feet apart in rows 10 feet apart will have about 545 vines. However, the actual number of bearing vines in most vineyards is somewhat less than the maximum possible. In poorly maintained vineyards, the actual number of vines may be less than 70 percent of the available vine spaces. Yield estimates can err significantly if estimates do not account for missing vines. To use an example, an estimate based on 545 bearing vines per acre might predict 4.9 tons of crop. Using the same average cluster weight (0.6 pound) and number of clusters per vine (30), the actual yield would be only 4.4 tons per acre if 10 percent of the vines were missing or were nonbearing. Unfortunately, it is not uncommon for 10 percent of the vines to be missing. Therefore, it is important to ensure that crop estimates are based on the actual number of bearing vines.

In some vineyards, the trellis spaces created by missing vines are filled in by extending cordons from adjacent vines. While this is a good practice to maintain vineyard productivity, it makes it more difficult to determine the number of vines per acre accurately and to estimate the crop successfully. An alternative is to count the number of panels (the distance between two consecutive posts in a row) per acre and to make counts of clusters per panel rather than clusters per vine.

Number of Clusters Per Vine

The average number of fruit clusters per vine is determined by counting clusters on representative vines and deriving an average figure from those counts. Crop can be estimated any time after all the flower clusters are exposed on the developing shoots. One advantage in waiting until after fruit set, however, is that the percentage of berry set can also be gauged. The vines on which clusters are counted should be selected methodically. One possibility is to sample on a grid — for example, inspecting every twentieth vine in every third row. The number of vines on which to count clusters depends on vineyard size and the uniformity of vines within the vineyard. In a 1- to 2-acre vineyard with vines of a uniform age, size, and training system, it might be necessary to sample only 10 or 15 vines. In larger, nonuniform vineyards, sampling should be stratified to account for variation between distinct areas of the vineyard. Bear in mind that the purpose of sampling is to determine the average number of clusters per vine for the entire vineyard. The larger the sample, the greater the likelihood that the sample average will be close to the vineyard average.

Average Cluster Weight

Cluster weights for each variety should be obtained annually at harvest and averaged. The results should then be averaged over all years for which data are available and used in making crop estimates. Clusters can be collected from picking bins after harvest, but the tendency in that sampling process is to select larger-than-average clusters. For each vine, record the total number of clusters picked, weigh them, and divide the weight by the number of clusters to obtain the average cluster weight. Subtract the weight of the empty picking bins from the total fruit weight. Picking all clusters from vines will ensure that you take into consideration the extremes in cluster size. Again, sampling 10 to 15 vines may be sufficient for a small, uniform vineyard.

Sources of Variation

After the number of bearing vines per acre (or block) and the average number of clusters per vine have been determined, these data can be combined with the average cluster weight to predict the crop yield per acre (or block). Unfortunately, the above discussion oversimplifies the crop prediction process somewhat. Even with thorough sampling, accurate vine counts, and many years' average cluster weight data, the actual crop tonnage at harvest can vary significantly from that which is predicted only two months before harvest. Many experienced producers are satisfied if the difference between predicted and actual yields is less than 15 percent. The most uncertain component of the crop prediction equation presented in this chapter is the average cluster weight. That uncertainty results from variation in the cluster weight components listed in Figure 12.1. Furthermore, environmental conditions, diseases, and insect pests affect cluster weights. A dry summer, for example, tends to reduce berry size and thus decrease average cluster weight. As Table 12.1 illustrates, a 1/10-pound difference in average cluster weight can result in a yield difference of nearly 1 ton per acre. Furthermore, the predicted yield does not account for fruit lost to bunch rots, birds, deer, or other unpredictable factors.

The crop prediction model can be refined to provide a more accurate estimate of actual crop yield if the grower is willing to invest extra time. The process involves repeated measures of cluster weight during the growing season. Those measures are then used to adjust the average harvest cluster weight predicted at harvest. Seasonal cluster weight data can be fitted to a regression model and that model can then be used to predict the harvest cluster weight. Regression analysis is a tool used to describe how a unit change in one variable (for example, number of days after bloom) affects another dependent variable (for example, average cluster weight). However, to derive a meaningful model (one in which the regression model accounts for a significant proportion of variation in cluster weight), it is necessary to sample cluster weight on a number of days during the growing season. This process is somewhat tedious and destructive.

Table 12.1. Variation in Yield Estimate with a 1/10-Pound Change in Average Cluster Weight

Number of Vines per Acre	Number of Clusters per Vine	Average Cluster Weight (lb)	Yield (tons/acre)
545	30	0.60	4.91
545	30	0.50	4.10

An alternative approach, suggested by researchers at Oregon State University (Price, 1992), involves determining the average cluster weight at the "lag phase" of cluster development and using that single measure to adjust the average harvest cluster weight. For this method, a historical average lag-phase cluster weight must

be developed for the vines in a vineyard. The lag phase of cluster growth corresponds to the lag phase of berry expansion that occurs with seed hardening. It can be measured as a temporary slowing of the otherwise linear increase in cluster weight throughout the season. The lag phase occurs about midway between bloom and harvest. Much, but not all, of the variation in harvest cluster weight is determined by this stage. Collect about 300 clusters during the lag phase, weigh them, and derive an average lag-phase cluster weight in the same manner used in determining the average harvest cluster weight. The crop prediction model is then modified to use both a historical average lag-phase cluster weight as well as the average lag-phase cluster weight for the current season to adjust the average harvest cluster weight as follows:
where:

S = lag-phase cluster weight for current season

A = historical average lag-phase cluster weight (several years' data)

H = average harvest cluster weight (several years' data)

Equation 12.2

$$\text{Estimated Yield (tons/acre)} = \frac{\text{Vines}}{\text{Block}} \times \frac{\text{Clusters}}{\text{Vine}} \times \frac{S}{A} \times H$$

Fitting some hypothetical numbers into this refined model will illustrate how a small change in the cluster weight during the lag phase will correspond to a change in the average harvest cluster weight.

Timing the lag phase of berry development is a potential source of variation with this technique. In Oregon, the cluster lag phase occurred about 55 days after first bloom, a period when the seeds of developing berries could no longer be cleanly cut with a sharp knife without the seed crushing the adjacent tissue of the berry.

Even using lag-phase cluster weights, it is necessary to take into account seasonal changes in water surpluses or deficits that can measurably affect cluster weights very close to harvest.

In conclusion, consider the following points:

- ☐ Good average cluster weight data are essential to predict the crop accurately. Do not rely on average cluster weight data from other vineyards. Long-term data will be more meaningful than a single year's data.
- ☐ Cluster-to-cluster variability is thought to be greater than vine-to-vine variability. Sample entire vines to develop the average cluster weights.
- ☐ Nonuniform vineyard blocks (for example, those where variations in soil, topography, vine age, or vine training occur) should be divided into uniform subblocks.
- ☐ The accuracy of yield estimates depends on representative sampling.
- ☐ Sampler variation can be significant. Use the same person each year to estimate crop.

Do not be discouraged if first attempts at crop estimation are inaccurate. The more experience and data acquired, the more accurate the estimates will become. Using crop prediction methods, you may determine that you have more than the desired amount of fruit per vine, and the extent of thinning required to achieve the target yield desired for the vineyard (Hellman and Casteel, 2003).

References

Hellman, E. W. and Ted Casteel. 2003. Crop estimation and thinning. In E.W. Hellman (ed.), *Oregon Viticulture,* 1st ed. Oregon Winegrowers' Association.

Price, S. 1992. Predicting yield in Oregon vineyards. In T. Casteel (ed.), Oregon Winegrape Grower's Guide, 4th ed. Oregon Winegrowers' Association.