# A Practical Method for Counting Berries based on Image Analysis

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The most accurate crop estimates in machine-pruned vineyards are based on measurements of average berry weights during the season, rather than cluster weights as is commonly done in hand-pruned vineyards (Pool et al., 1996). As machine pruning becomes more popular, methods for crop estimation methods will need to improve, in particular methods for counting berries.Currently the only feasible way to count berries is to do so manually. Manual counting may be practical if the number of clusters to be counted is not large, but if a significant amount of counting needs to be done, the manual method quickly becomes extremely tedious, inefficient, and very often inaccurate.

This work demonstrates a novel method of using a common flatbed scanner to take an image of a sample of loose grape berries, and subsequently counting the imaged berries with a software program. The advantage of this method is that it offers a much quicker and more reliable count of large numbers of berries; this should make it particularly attractive for both researchers and vineyard managers who require significant amounts of berry counts to be made.

## Materials and Methods

All scanning was done with a Canon scanner, model "Canoscan LiDe 90", set to scan in grayscale mode with a 200 dpi resolution, with the output saved as JPEG images. A separate glass berry tray was made by gluing ½" aluminum angle stock around the edges of an 8 ½" x 12" rectangular piece of 1/8" thick window glass, forming a flat, clear-bottomed tray with raised edges. The loose berries were then placed onto this glass tray, and the tray placed directly onto the platen (clear surface) of the scanner. The underside of the berry tray which was directly beneath the aluminum edges was covered with a ¾" wide strip of black electrical tape, to prevent any light-colored aluminum from showing up in the scanned image. The top of the scanning tray was covered with dark-colored cardstock during scanning, in the same way as the normal scanner lid is used.

Eight clusters containing small pea-sized berries were removed from a local Pinot Noir vineyard on June 2, 2008. A sample of 250 random berries was removed from these clusters and used for testing.

To determine the accuracy of the counting method, all 250 berries were placed onto the glass berry tray and scanned. The glass tray was then lifted off of the scanner and shaken to move all berries, and then replaced and the image was scanned again. This process was repeated a total of five times, producing the initial grayscale images (Fig. 1).

The grayscale images were then opened with the ImageJ® image analysis program, and converted to binary black/white images. The binary images were then processed with the "*Watershed*" command, which divided any berries which were adjoining in the image (Fig. 2). Lastly, using the "*Analyze Particles*" function, the software counted the individual berries; a threshold particle size was set, to avoid errors due to counting of any small bits of debris in the image.

To test the ability of the method to measure berry size (cross sectional area), five groups of 20 berries were selected. The length and width of each berry was measured manually using hand calipers, and the cross sectional area of each berry was then calculated assuming an oval cross section. Each group of 20 berries was then placed in a single line on the scanning tray and processed following the method described earlier, the only difference being that when the "*Analyze Particles*" function was used, that an option which listed the area for each measured particle was also enabled.

## Results and Discussion

The method proved to be completely accurate in counting the 250 berries; each analysis produced the same count of 250. This accuracy of counting immature berries matched the same accuracy seen in earlier tests with dried beans and fresh peas, before actual berries were available.

The correlation between the measured berry cross-sectional area and the area based on the image analysis was less accurate, with an r^2 value of 0.67, and a slight tendency for underestimation. This low correlation is likely due to the edges of the berries being out of focus in the images, because they are relatively farther away from the platen surface. This limits the use of the method for estimating absolute cross-sectional areas accurately for spherical objects such as berries, but it does not appear to be a limitation for counting particles.

Overall, the method is much faster than manual hand counting for large numbers of berries. A significant advantage of this method over other potential counting devices is that it is very inexpensive to implement; a new scanner can be purchased for less than $100, and the image analysis software is available at no cost from the NIH website (http://rsb.info.nih.gov/ij/). The simple glass berry tray was built for less than $10 in materials. A person proficient with the method can comfortably and accurately count a sample of loose berries in much less time than is required for manual counting.

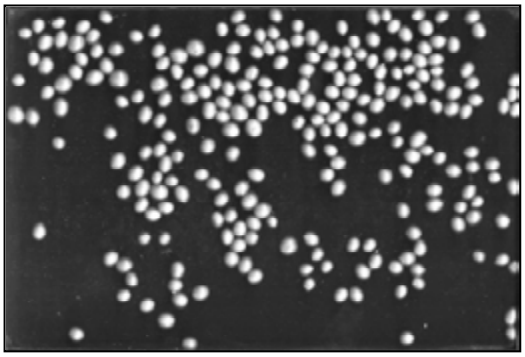


**Figure 1.** One of the raw scanned images; a black background is used with the scanner so that the green immature berries stand out distinctly. If scanning of mature, dark-colored berries is to be done, then the background should be changed to the standard white color.

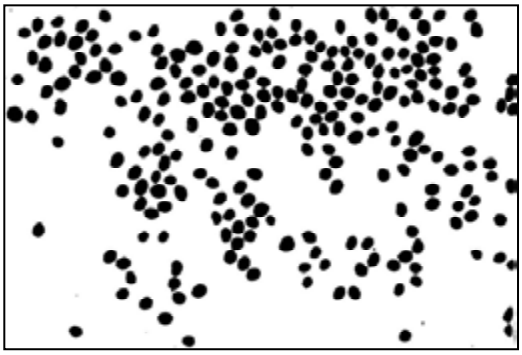
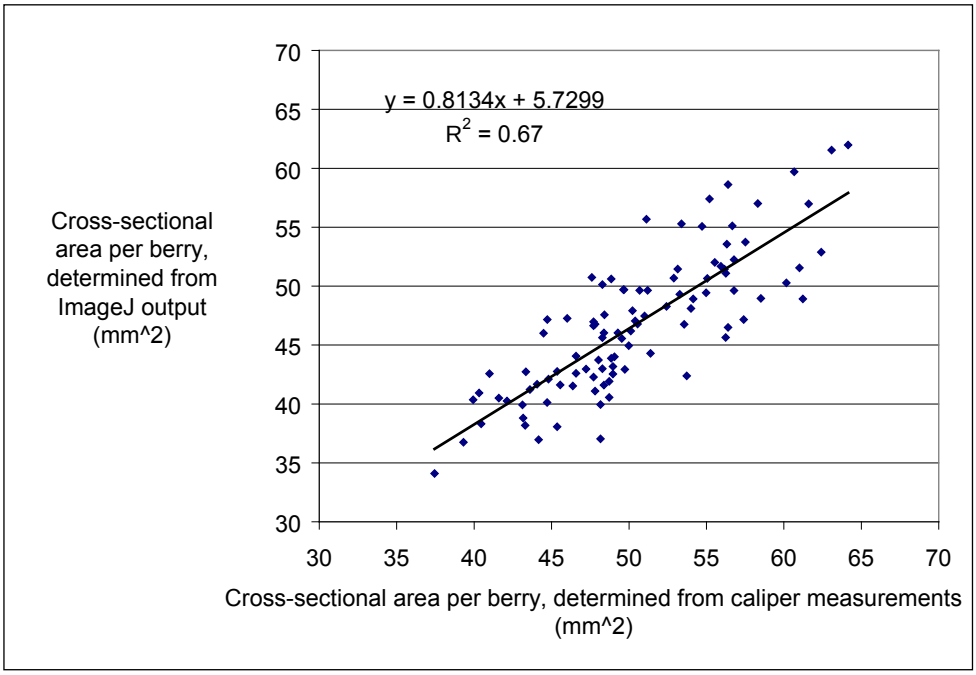


**Figure 2.** The raw image converted to a binary black/white image in the ImageJ® program. Any small specks of debris are ignored in the count by setting a minimum threshold size of particle to be considered in the count.

**Figure 3.** Correlation between the manually measured berry cross sectional area and the area estimated from image analysis.




## References

Pool, R. M., R. M. Dunst, et al. Predicting and controlling crop of machine and minimal pruned grapevines. In: Proc. 2nd N.J. Shaulis Grape Symposium, Fredonia, NY. pp 31-45 (1993).