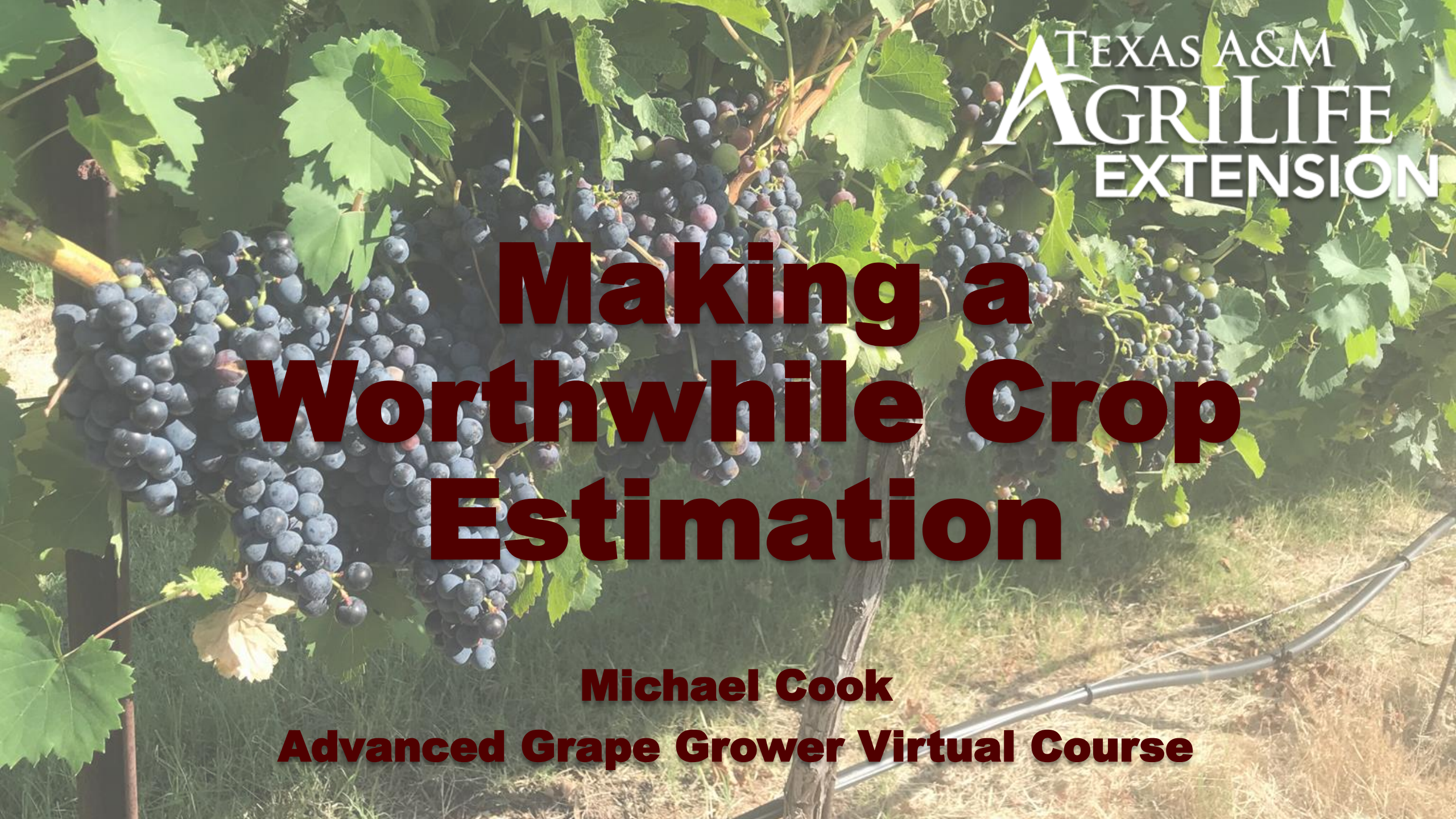


Making a Worthwhile Crop Estimation

Michael Cook

Advanced Grape Grower Virtual Course

Why is it important to be accurate?

For you the Grower:

- grower-winemaker relationship, builds trust
- plan for harvest logistics, supplies, labor
- estimate income
- helps with determining crop load adjs.
  - pruning weight
  - Ravaz index (current yield / following pruning weights)
  - Growth-Yield Relationship

Why is it important to be accurate?

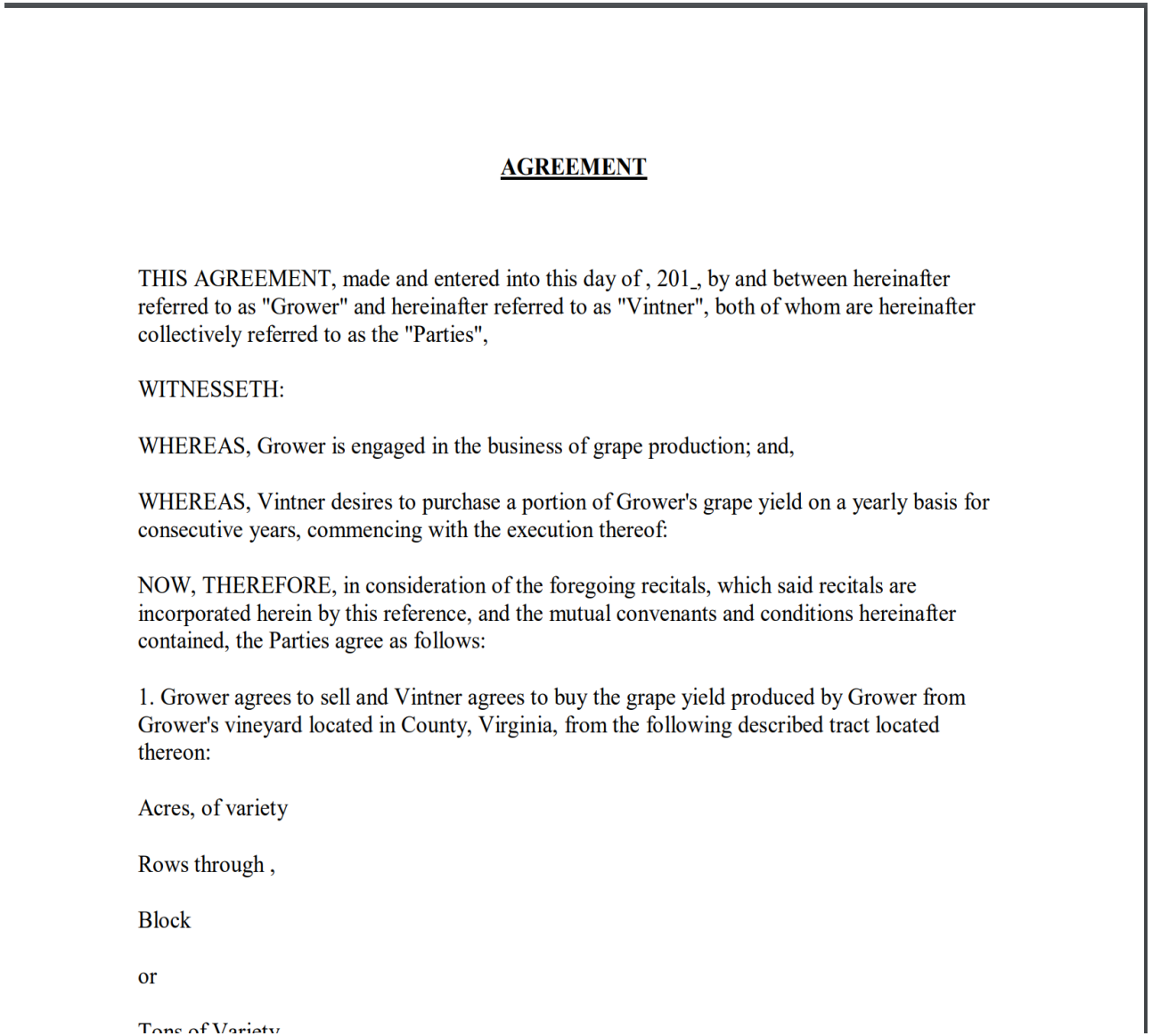
For the Winemaker:

- grower-winemaker relationship, builds trust
  - tank and barrel space required
  - scheduling logistics
  - estimate payment
  - quality driven/vine balance?

Friendly Reminder

Grower-Winemaker Contract

- plan ahead
- each situation different
- best not go looking for a buyer once the fruit is in the bins



AGREEMENT

THIS AGREEMENT, made and entered into this day of , 201_, by and between hereinafter referred to as "Grower" and hereinafter referred to as "Vintner", both of whom are hereinafter collectively referred to as the "Parties",

WITNESSETH:

WHEREAS, Grower is engaged in the business of grape production; and,

WHEREAS, Vintner desires to purchase a portion of Grower's grape yield on a yearly basis for consecutive years, commencing with the execution thereof:

NOW, THEREFORE, in consideration of the foregoing recitals, which said recitals are incorporated herein by this reference, and the mutual convenants and conditions hereinafter contained, the Parties agree as follows:

1. Grower agrees to sell and Vintner agrees to buy the grape yield produced by Grower from Grower's vineyard located in County, Virginia, from the following described tract located thereon:

Acres, of variety

Rows through ,

Block

or

Tons of Variety

Farming is full of uncertainty?

1. normal to see 10-20% variation in yields from year to year with mature fully trained vines

Two things that act against normalcy

1. **viticulture is intensive farming and long term perennial crop**
   - requires lots of inputs to keep a healthy vine in balance
2. **we live in Texas…**

Crop Potential: influenced by lots of things

- Environment
- Soils
- Water availability
- Cultivar
- Rootstock
- Vineyard design
- Vineyard floor management
- Nutrition
- Diseases and pests
- Management practices
- Production goals

Average "Normal Year" Yields in Texas

- *Vinifera:* 2-4 tons per acre
- Hybrids: 3-6 tons per acre
- Blanc du Bois - 0.3-.4 lbs. per cluster
- Black Spanish - 0.4-.5 lbs. per cluster

United States Department of Agriculture
National Agricultural Statistics Service

2019 Texas Wine Grape Varieties

Southern Plains Regional Field Office · Post Office Box 70, Austin, Texas 78767 · 800-626-3142 · www.nass.usda.gov

Texas Wine Grape Production Continues Growth

Texas wine grape growers produced 14,180 tons of grapes from 5,020 bearing acres in 2019. Production was up 22 percent from 11,660 tons produced in 2017. Bearing acres in vineyards for 2019 were up 11 percent from 4,541 acres from the last survey conducted in 2017. The average yield of 2.8 tons per acre was up 0.2 tons from the previous survey. The total value of wine grape production in Texas for 2019 was estimated at $22.7 million, compared with $18.9 million in 2017.

Distinct Wine Grape Growing Regions of Texas: 2019

Region Name	Acres		Tons	
	Bearing	Non-Bearing	Production	Yield per Bearing Acre
Texas High Plains and Panhandle	3,000.0	220.0	10,300	3.4
North Texas (DFW)	500.0	210.0	680	1.4
Southeast Texas and Gulf Coast	300.0	95.0	470	1.6
West Texas	390.0	25.0	970	2.5
Hill Country	830.0	260.0	1,760	2.1
Total [1]	**5,020.0**	**810.0**	**14,180**	**2.8**

See footnote(s) on page 7.

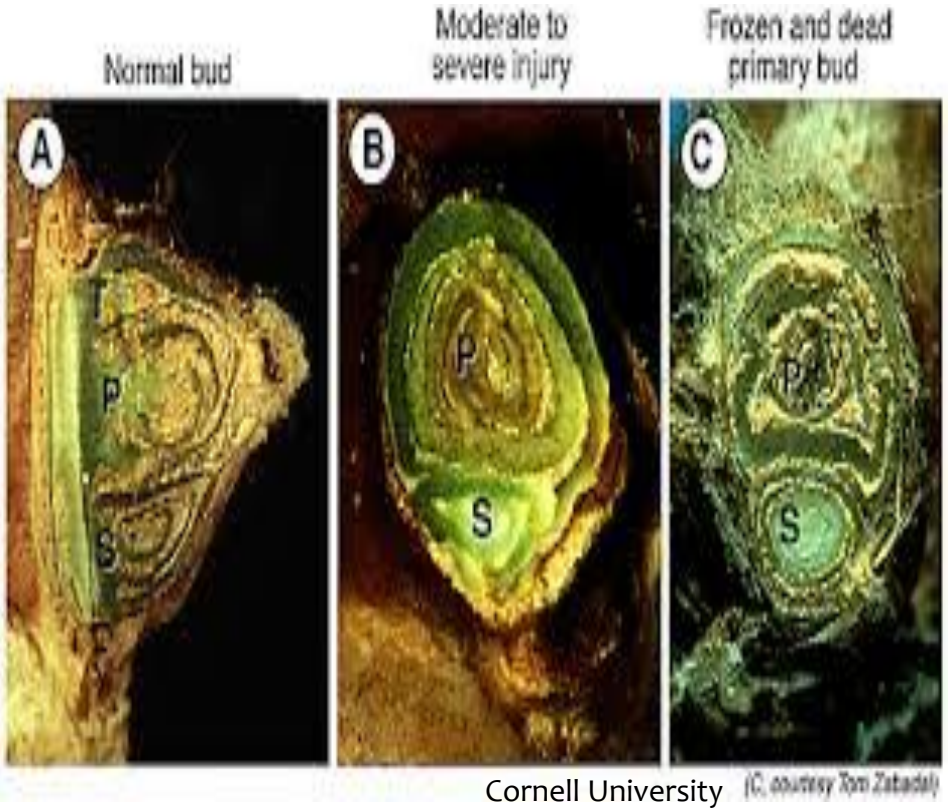
“Acts of God” that impact yield?

1. Weather
2. Pestilence
3. Vertebrates
4. Hail
5. Tornado/Hurricane
6. Sunburn
7. Drought/Flood
8. Herbicide Injury (Act of Man)

Crop Estimation – Let's Begin

- Begins with dormant pruning
  - overall health evaluation
  - bud dissection
  - how many fruitful buds do you leave on the vine
    - vine balance

https://www.youtube.com/watch?v=RSvQ8bXNd_8



Cornell University (C, courtesy Tom Zabadal)

Our Goal…

to be <10% +/- of actual harvest tonnage

Ex. estimated 3 tons per acre +/- 600 lbs.

Four Ways to Estimate Your Crop

1. eye-ball
2. traditional method
3. lag-phase method
4. remote/proximal sensors - PV

- keep records!

Eye Ball Method

- if you can get within 5% just by eye-balling it, I want to hire you.

Advantages

- cheap, quick, no special tools

Disadvantages

- highly subjective and inaccurate

Not recommended…

Traditional Method

- Based on historical records of cluster wt. at harvest
  - variety and block specific
- Can only be done once you have harvest data from previous years
  - new growers can take destructive wt counts 1-2 weeks before harvest
  - can be done multiple times throughout season

Potential Yield t/acre = (#BVA x #CV x CW)/2000

#BVA – only count bearing vines per acre

#CV - best to take count right after fruit-set

Traditional Method – Cluster Wt.

To determine mean **cluster weight:** weight (lbs.) clusters per vine divided by number of clusters, during harvest

- no Xmas clusters*

OR

1-3 acres = 100 clusters per acre is sufficient if the vineyard is uniform (Dami 2006).

5+ acres = weigh 200–400 clusters (Hellman and Casteel 2003)

Using berry weight

- can be used to assess cluster weight, b/c estimate would be higher
- best for mechanical harvested vineyards
  - rachis accounts for up to 2-5% error (Dookozlian 2000)

Using Berry Weight to Estimate Cluster Weight

Another type of in-season estimation is to use the average berry weight and the average berries per cluster to determine total cluster weight. This method, common in juice grape production, allows tracking of annual changes in berry size and can provide more accurate yield predictions if a vineyard is mechanically harvested. In comparison, handpicking introduces 2–5% yield estimation error because the cluster rachis is included in the berry weight (Dokoozlian 2000). This component of yield is not a factor in mechanically-harvested vineyards because the cluster rachis is left behind (Figure 3).

In many cases, it is necessary to sample 100–200 berries to get an accurate estimate. Berries should be selected from different vines, as there is typically more between-vine variation in a vineyard than between-cluster variation (Rankine et al. 1962).

Berry weights can be incorporated into both the traditional and lag phase estimation methods. (The 0.0022 multiplier converts berry weights in grams to pounds.)

Yield (tons per acre)=

$$\left(PV \times CV \times \frac{\text{berries}}{\text{cluster}} \times BW_{Harvest} \times \frac{0.0022\ g}{lb} \right) \frac{2000\ lb}{ton}$$

Equation 2a: Traditional Yield Estimation with Berry Weights

Yield (tons per acre)=

$$\frac{\left(PV \times CV \times \frac{\text{berries}}{\text{cluster}} \times BW_{Lag} \times \frac{0.0022\ g}{lb} \times HM \right)}{\frac{2000\ lb}{ton}}$$

Equation 2b: Lag Phase Yield Estimation with Berry Weights

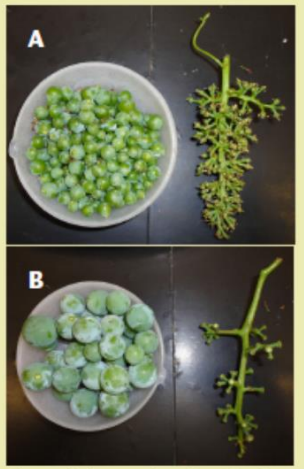


Figure 3. A) A comparison of contributing cluster weight factors from the rachis and berries in a Vitis vinifera *'Chardonnay' cluster; B) A comparison of contributing cluster weight factors from the rachis and berries in a* Vitis labruscana *'Concord' cluster. Photos by Brittany Komm.*

Based on the data in Table 4, yield estimation for Crimson Vineyards using berry weights is calculated in Example Equations 2a and 2b with traditional and lag phase estimation elements, respectively.

Yield Potential (tons per acre)=

$$\frac{\left(\frac{726\ \text{vines}}{\text{acre}} \times \frac{177\ \text{clusters}}{\text{vine}} \times \frac{30\ \text{berries}}{\text{cluster}} \times \frac{2.72\ g}{\text{berry (harvest)}} \times \frac{0.0022\ lb}{g} \right)}{\frac{2000\ lb}{ton}} =$$

$$\frac{\left(\frac{23130.36\ lb}{\text{acre}} \right)}{\frac{2000\ lb}{ton}} = 11.57 \frac{\text{tons}}{\text{acre}}$$

Example Equation 2a: Harvest Yield Estimation with Berry Weights for Crimson Vineyards.

Yield Potential (tons per acre)=

$$\frac{\left(\frac{726\ \text{vines}}{\text{acre}} \times \frac{177\ \text{clusters}}{\text{vine}} \times \frac{30\ \text{berries}}{\text{cluster}} \times \frac{1.36\ g}{\text{berry (lag)}} \times \frac{0.0022\ lb}{g} \times 2 \right)}{\frac{2000\ lb}{ton}} =$$

$$\frac{\left(\frac{23130.36\ lb}{\text{acre}} \right)}{\frac{2000\ lb}{ton}} = 11.57 \frac{\text{tons}}{\text{acre}}$$

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Lag-Phase Method

- based on cluster weights during the growing season with the idea that weight of clusters will double after lag-phase

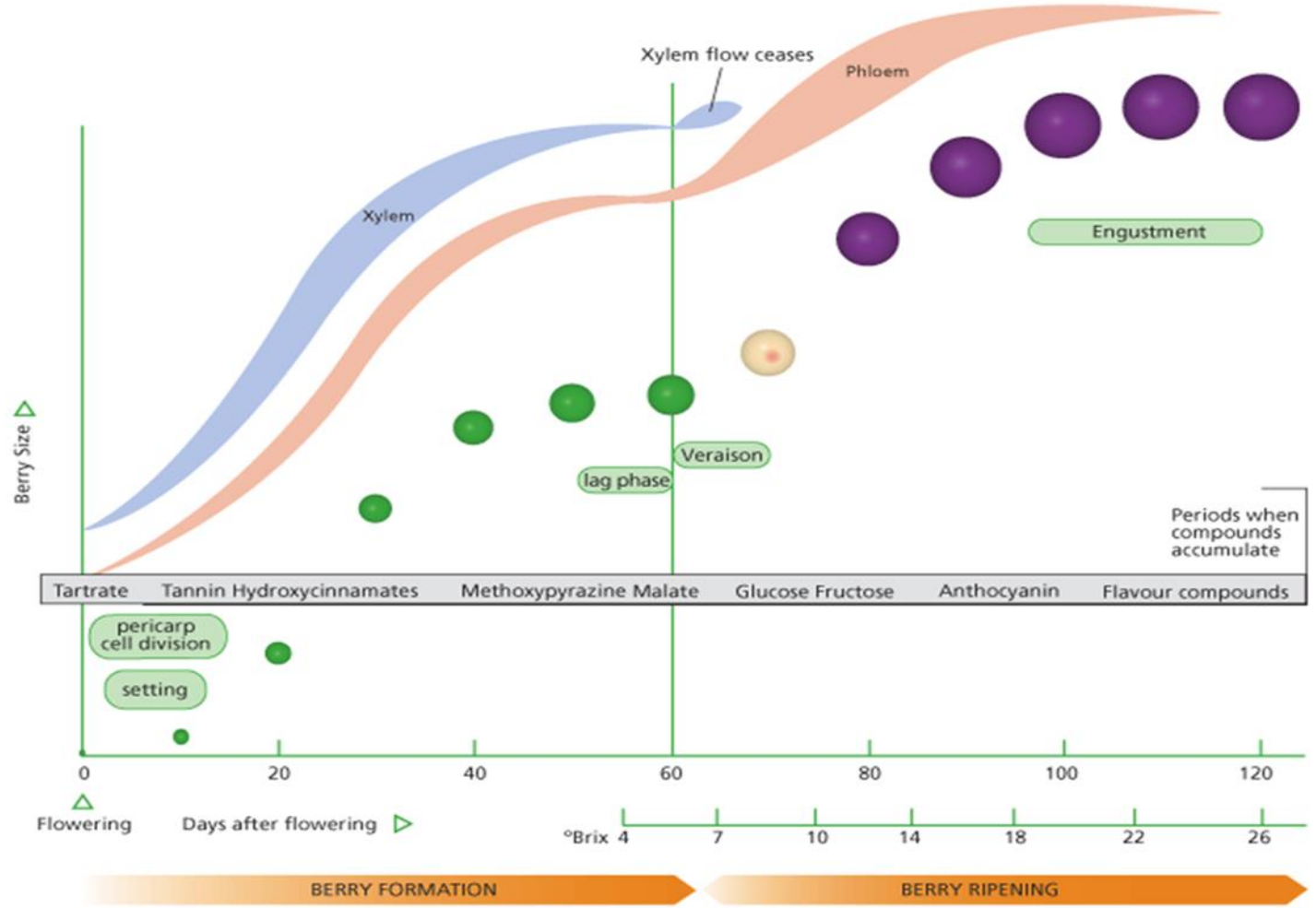

Figure 2: Diagram showing relative size and color of berries at 10-day intervals after flowering, passing through major developmental events (rounded boxes). Also shown are the periods when compounds accumulate, the levels of juice °brix, and an indication of the rate of inflow of xylem and phloem vascular saps into the berry. Illustration by Jordan Koutroumanidis, Winetitles.

Lag-Phase Method

- lag-phase occurs around 50-60 days post bloom, sample when 90% of seeds are resistant to knife
- is a destructive method

PY = (#BVA x #CV x LagCW x 2.0)/2000

Increase factor (2.0) may be adjusted over time

Sampling protocol for either method

How many vines to sample?

- **Small vineyard:** with a few hundred vines sample 20-25% of vines
- **Large scale vineyard:** sample at least 2% (15 vines per acre)
  - 5% better
- **Z** or **W** pattern to limit variability and enhance accuracy
- Be meticulous, your data is only as accurate as your sampling protocol!

Z/W Pattern

- keep data vines random but select representative vines!
- yield can vary spatially within blocks

Quantitative Methods

Advantages

- can achieve accuracy goal, requires no expensive equipment

Disadvantages

- Lag Phase Method is destructive, does take time, inaccurate if not performed properly (human error with subjectivity), spatially sparse

Reasons you aren't reaching your goal

1. *No historical cluster weights on vineyard site*
2. *Didn't map non-bearing vines annually*
3. *Acts of God leading to non-average growing season*
4. *Didn't collect representative vine samples across the site*
5. *Cluster numbers were not robust enough to limit variability*

Proximal Remote Sensing Technology

Texas A&M AgriLife Extension

Counting Berries per Vine

counting clusters via automation is inaccurate

- number of Clusters per vine = 60% of yield variation
- number of Berries per Cluster = 30% of yield variation
- size of berries (wt.) = 10% of yield variation

- Nuske et al. accounts for the first two by counting berries per vine with visible light camera and estimates yield by a yield forecasting function

Let's Check It Out…

Texas A&M AgriLife Extension

UC-Davis – Kaan Kurtural

- 4 sensor camera
  - adjustable to trellis
- crop estimation algorithm in progress
- multi positioned cameras helps minimize error due to leaf occlusion
- estimated cost $50,000

Winebusiness.com

Texas A&M AgriLife Extension

Sensor Technology

Advantages

- can achieve accuracy goal, extremely fast, low labor requirement, non-destructive

Disadvantages

- expensive, requires specialized equipment and skilled operator, occlusion, algorithms still in development to improve average accuracy

Current R&D

- Trellis tension monitors
- Multi-spectral sensors
- Tera-hertz wave imaging (picks up curved surfaces, i.e. berry)
- 2 and 3D RGB
  - UAVs

METHODS ARTICLE

Front. Plant Sci., 03 May 2019 | https://doi.org/10.3389/fpls.2019.00559

Check for updates

A Low-Cost and Unsupervised Image Recognition Methodology for Yield Estimation in a Vineyard

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Yield prediction is a key factor to optimize vineyard management and achieve the desired grape quality. Classical yield estimation methods, which consist of manual sampling within the field on a limited number of plants before harvest, are time-consuming and frequently insufficient to obtain representative yield data. Non-invasive machine vision methods are therefore being investigated to assess and implement a rapid grape yield estimate tool. This study aimed at an automated estimation of yield in terms of cluster number and size from

TEXAS A&M AGRILIFE EXTENSION

Crop Load and Vine Balance

- **Source (leaf) and Sink (fruit) relationship**
  - Under-cropped: too much source, not enough sink
  - Over-cropped: too much sink, not enough source

Photos courtesy of Dr. Justin Scheiner, TAMU

Texas A&M AgriLife Extension

Crop Thinning

- When flower clusters are visible
  - after fruit-set
- After danger of frost has past

- Before veraison: reduce yield, avert over-cropping
- End of veraison: reduce unevenness

Shoot Thinning

Photos courtesy of Dr. Justin Scheiner, TAMU

Cluster Thinning

Texas A&M AgriLife Extension

Questions?

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