COMPARISON OF CALIFORNIA HERITAGE ZINFANDEL AND PRIMITIVO GRAPEVINE SELECTIONS in Napa Valley, California

MARCH 19, 2015

MICHAEL PENN
M.S. VITICULTURE & ENOLOGY

Summary

1) Zinfandel in California
2) Old World Counterparts
3) Clonal variation. Mechanisms and observations
4) Zinfandel Heritage Block at the Oakville station
5) Data from Oakville: Past & Present
### 2013 NASS California Acreage and Crush Report

<table>
<thead>
<tr>
<th>Crushed Tons (all reds)</th>
<th>Crushed Tons (Zinfandel)</th>
<th>Percent (Zinfandel)</th>
<th>Crushed Tons (Primitivo)</th>
<th>Percent (Primitivo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,416,378</td>
<td>469,215 (2\textsuperscript{nd} for red)</td>
<td>19.4%</td>
<td>1,893 (24\textsuperscript{th})</td>
<td>0.08%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Winegrape Acreage</th>
<th>Total Red Winegrape Acreage</th>
<th>Bearing Acres (Zinfandel)</th>
<th>Non-bearing Acres (Zinfandel)</th>
<th>Bearing Acres (Primitivo)</th>
<th>Non-bearing Acres (Primitivo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>494,192</td>
<td>308,698</td>
<td>47,624 (2\textsuperscript{nd})</td>
<td>1,104 (5\textsuperscript{th})</td>
<td>327 (21\textsuperscript{st})</td>
<td>446 (7\textsuperscript{th})</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wtd. Avg. S/ton (Zinfandel)</th>
<th>Gross Value (Zinfandel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$715.31</td>
<td>$335,634,181.00</td>
</tr>
</tbody>
</table>

### Tons of Winegrapes Crushed in 2013 by District

#### Crush Picking Districts:

- **Chardonel**: 26,550
- **Carmanah**: 35,133
- **Zinfandel**: 37,615
- **Petite Sirah**: 31,674
- **Sangiovese**: 30,452
- **Muscat of Alexandria**: 3,068

- **Sonoma Valley**: 141,192
- **Marin**: 22,480
- **Sonoma Coast**: 11,325
- **Napa Valley**: 11,013
- **Lake County**: 9,286
- **Shasta**: 7,332
- **Lodi**: 6,193
- **San Joaquin Valley**: 5,447
- **Central Valley**: 5,336
- **Monterey**: 3,140
- **Santa Maria Valley**: 2,690
- **Santa Barbara**: 2,604
- **San Luis Obispo**: 2,233
- **Ventura**: 2,082
- **San Diego**: 1,423
- **Orange County**: 1,093
- **Los Angeles**: 1,036
- **37,205**

#### Total Tons Crushed in 2013:

- **Chardonel**: 3,366,361
- **Carmanah**: 2,109,999
- **Zinfandel**: 2,416,378
- **Petite Sirah**: 1,778,277
- **Sangiovese**: 1,522,756
- **Muscat of Alexandria**: 148,363
- **Sonoma Valley**: 504,277
- **Marin**: 204,396
- **Sonoma Coast**: 153,396
- **Napa Valley**: 99,522
- **Lake County**: 57,290
- **Shasta**: 45,535
- **San Joaquin Valley**: 39,642
- **Central Valley**: 53,263
- **Monterey**: 1,144
- **Santa Maria Valley**: 1,022
- **Santa Barbara**: 679
- **San Luis Obispo**: 397
- **Ventura**: 287
- **San Diego**: 172
- **Orange County**: 119
- **Los Angeles**: 74
- **Total**: 4,520,077
FPS Registered Zinfandel Selections

- 47 Zinfandel clones
- 3 Primitivo clones
- 2 Pribidrag clones changed to Zinfandel 42 and 44 in 2012
- Crljenak kastelanski changed to Zinfandel in 2012 as well!

(National Grape Registry, 2014)

Ampelography

- **Clusters**: medium to large; cylindrical to long conical, often winged, sometimes with double wings, compact; short to medium-length peduncles; often with a wide range of ripe and under-ripe berries.
- **Berries**: medium to large; round to oblate; deep blue-black; prominent rust-colored stylar scar.
- **Leaves**: medium to large; deeply 5-lobed, often overlapping; lyre-shaped petiolar sinus; long, jagged teeth; dense hair on lower leaf surface.
- **Shoot tips**: downy to felty; young leaves bronze-red.

Charles Sullivan

- Professor of History, Los Gatos Community College
- Zinfandel first in America via George Gibbs of Long Island, NY from the Schoenbroen Palace, Vienna, 1829
- “you may depend on [them] as genuine as I received them from the Imperial Garden at Schoenbrunn”
  
  - A letter received by William Robert Prince of Long Island in 1830 from his neighbor, George Gibbs

...Long Island, New England...

1) 1830, George Gibbs, Long Island nurseryman, gives “Black Zinfardel of Hungary” to William Robert Prince
2) 1830, Gibbs gives “Zenfendal” to Samuel Perkins, Mass. Hort. Society
3) 1833, Zinfandel noted as a suitable table grape, widely planted from NY to Maine in greenhouses
4) 1844, James Warren lists “Zinfendel” in his Boston-based nursery catalogue
...California Zinfandel

1) 1852, Capt. Macondray sails from Boston to California with a supply of vines and trees, begins a nursery in San Francisco

2) 1852, J.W. Osborne grafts over Oak Knoll vineyard to Zinfandel and other varieties from Macondray

3) 1852, Antoine Delmas imports “Black St. Peters” to his nursery in Santa Clara. Supplies Mariano Vallejo’s viticulturist as well as William McPherson Hill

4) 1853, A.P. Smith imports “Zeinfandall” to Sacramento nursery, supplies foothills.

Eugene W. Hilgard

- Examination of Zinfandel wines (1884)
- Analyzed body, alcohol, tannin, and acidity
- “the great bulk of Zinfandels in the State will need to be blended and the blends must vary considerably with the locality.”

- “…the white zinfandel often develops a very agreeable bouquet.”
George Hussman

• “Zinfandel, or Zinfandl, as some call it. The true origin and dissemination of this important variety is not yet clear... Be that as it may, it has proven of great value in developing the wine industry of the State, as it proved that a really good, red wine, resembling choice claret, could be made in this state... I have yet to see the red wine of any variety, which I would prefer to the best samples of Zinfandel produced in this State.

• Unfortunately these best samples are like angels visits, ‘few and far between’

- 1888, Grape Culture and Winemaking in California: A Practical Manual for the Grape-grower and Wine-maker

2) Old World Counterparts - Italy?

• 1967, USDA Plant Pathologist Austin Goheen tastes Primitivo while visiting colleague Dr. Giovanni Martelli at the Instituto di Patologia Vegetale in Bari, Puglia, Italy

- USDA, ARS, National Genetic Resources Program. 2015. Germplasm Resources Information
Primitivo

- 1968, planted at Tyree Vineyard, Davis. 
  Ampelographically identical.
- Wolfe (1976) shows identical isozyme fingerprint
- Bowers et al. (1993) show identical Restriction Fragment Length Polymorphism (RFLP) markers
- Franks et al. (2001) confirm using Simple Sequence Repeats (SSR) markers

Franks et al. 2001

Primitivo

- Oldest historical note
- 1799, a priest named Francesco Filippo Indelicati (1767-1831) notes in the Gioia town records of his selection of an earlier ripening vine from among a population of Zagarese (from Zagreb).
  (Robinson et al., 2012)

Gioia del Colle
Croatia?

- Mike Grgich convinced that Plavac Mali is Zinfandel...Croatian chapter begins (Piljac, J. 2004)
- Zinfandel is not Plavac Mali, but does have parent-offspring relationship with Plavac Mali, Grk, Vranac, and Plavina. All found in Croatia (Maletic et al., 2004)
- Zinfandel is Crljencak Kastelanski. 9 vines found near Split, Croatia, 2001 (Maletic et al., 2004)
- Zinfandel is also...Tribidrag and Pribidrag in Croatia and Kratosija in Montenegro (Calo et al., 2008)

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### Microsatellite Data

<table>
<thead>
<tr>
<th>Locus</th>
<th>Zinfandel</th>
<th>Plavac Mali</th>
<th>Dobrščak</th>
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<tr>
<td>VWM05</td>
<td>290, 255</td>
<td>295, 259</td>
<td>279, 259</td>
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<tr>
<td>VWM06</td>
<td>212, 214</td>
<td>212, 212</td>
<td>212, 214</td>
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<tr>
<td>VWM07</td>
<td>247, 249</td>
<td>247, 249</td>
<td>247, 249</td>
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<tr>
<td>VWM08</td>
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<td>246, 249</td>
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<td>VWM11</td>
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<td>212, 210</td>
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<td>VWM02</td>
<td>243, 243</td>
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<td>VWM05</td>
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<tr>
<td>VWM07</td>
<td>199, 181</td>
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<td>199, 179</td>
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<tr>
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<td>212, 214</td>
</tr>
<tr>
<td>VWM02</td>
<td>257, 255</td>
<td>255, 257</td>
<td>255, 255</td>
</tr>
<tr>
<td>VWM05</td>
<td>244, 244</td>
<td>244, 247</td>
<td>244, 247</td>
</tr>
<tr>
<td>VWM07</td>
<td>130, 140</td>
<td>140, 145</td>
<td>145, 151</td>
</tr>
</tbody>
</table>


(Maletic, E., Pejic, J., and Meredith, C. 2004)
Microsatellite Data

Table 2. SSR profiles of 15 individual accesses (allele lengths in bp).

| SSR loc | Dubrovnik | Dalmatia | Fiume | Istria | Karlovac | Kvarner | Istria | Kvarner | Vrlika | Dalmatia | Dubrovnik | Dalmatia | Fiume | Istria | Karlovac | Kvarner | Vrlika | Dalmatia | Dubrovnik | Dalmatia | Fiume | Istria | Karlovac | Kvarner | Vrlika |
|---------|------------|----------|-------|--------|----------|---------|--------|---------|--------|----------|------------|----------|-------|-------|--------|----------|---------|--------|----------|------------|----------|-------|-------|--------|----------|---------|--------|
| VV02    | 120        | 140      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 120      | 140   | 130   | 130    | 130      | 130     | 130    |
| VV03    | 140        | 140      | 140   | 140    | 140      | 140     | 140    | 140     | 140    | 140      | 140         | 140      | 140   | 140   | 140    | 140      | 140     | 140    |
| VV04    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV05    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV06    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV07    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV08    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV09    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV10    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV11    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV12    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV13    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV14    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV15    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV16    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV17    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV18    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV19    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |
| VV20    | 130        | 130      | 130   | 130    | 130      | 130     | 130    | 130     | 130    | 130      | 130         | 130      | 130   | 130   | 130    | 130      | 130     | 130    |


Stjefan Bulic (1865-1937)
Croatian Ampelographer
Croatian Ampelography

68. Tribidrag crni
Synonyms: Tribirad, Tribidrag
Origin: ???
References: -

Areas of cultivation:
Dalmatia- In the past it was cultivated on the island Brac. Now, I think, there is not even a track of it anywhere
Other places/abroad - ?

Botanical Characteristics:
Top of shoots are thin, slightly curly, dark green and woolly. Leaf is middle size, symmetrical, rounded or wide, deep profiled, with 5-7 arms (?); Petiole is red and brushy, obverse is clean, reverse has tomentose,...
Flower is proper/correct. Cluster is small, cylindrical, with space between berries or compacted, stem of cluster is long and thin. Berries are middle size, spherical, dark blue, juicy and sweet.

Vineyard facts:
Vines of medium vigor, low yield, resistant to disease.
Budbreak in 4th, flowering and ripening in 3rd era.
3) Clonal variation. Mechanisms and observations

• 1) Age
  • Older varieties have accrued more mutations

• 2) Environmental conditions of stress
  • Spontaneous somaclonal mutations

• 3) Clonal diversity
  • Selection by vigneron

Mechanisms to clonal polymorphisms

• Variegation
  • Defective plastids, mutations in chloroplasts and mitochondria

• Transposons
  • Many in grapes (41% of genome), gret1 for color

• Somaclonal variation
  • Most common in grapevines. Genetic mutations

• Epigenetic modifications
  • DNA methylation...???

• Viruses and viroids
  • (Pelsy et al. 2010)
Tranposons

- 41% of grape genome! (Jaillon et al. 2007)
- Gret1 responsible for white color mutants (Kobayashi 2004)

Expression of UFOT is controlled by a myb gene designated VvmybA1
Mutation causing loss of color in white grapes is a Gret1 retrotransposon
Insertion into a VvmybA1 gene. Red revertants from white grapes arise when
The Gret1 is excised leaving part of the Gret1 behind.

Somaclonal Mutations

- Chimera- A plant that is a mixture of two distinct genotypes
- Bud sport- A phenotypical change in a plant issuing from a single bud
Somaclonal Mutations

- Rare...but they happen.
  - 1) Slippage of DNA polymerase
    - Exons account for 6.9% of grapevine genome!
  - 2) Mutation in shoot meristem cell
  - 3) Periclinal growth of mutated cell to become distinct cell layer
  - 4) Periclinal chimera must survive annual pruning
  - 5) Must be selected for vegetative propagation

(Hocquigny et al. 2004)

Shoot Apical Meristem

- Tunica corpus meristem
- Tunica- outside layer of cells
- Corpus- unlayered structure
- L1 (outer) grows periclinal (perpendicular to surface)
- L2 (middle) grows anticlinal, then periclinal
What would we expect to be different in a clone?

- Possible Somatic Mutations
  - Color (transposons, Pinot Blanc vs. Pinot Noir)
  - Flavor (terpene synthesis, Gewurztraminer vs. Savagnin rose, or musque clone of Chardonnay)
  - Date of ripening
  - Canopy growth habit and vigor
  - Size and compactness of clusters
  - Fruitfulness
  - Disease susceptibility (mildews, viruses, bacteria)
Aroma variation

(Chardonnay vs. Savagnin)

Concentrations of limonol and geraniol
in skins (µg/g)

Old Vine Differentiation

- How much difference would we expect?
  - V. vinifera genomes
    - 6.9% exons
    - 36.7% introns
    - 34.7% intergenic sequences
      - (Jaillon et al, 2007)
  - Older varieties (Pinot, Riesling, Traminer) have had more time to accumulate somatic mutations
  - Savagnin and Pinot noir were found to have 17 and 15 clonal genotypes compared to Cabernet Sauvignon and Chenin blanc which had 6 and 7 respectively (Pelsy et al 2010)
Genetic Variation of Zinfandel/Primitivo/Tribidrag


- Vitis 44 (3), 147–148 (2005)

<table>
<thead>
<tr>
<th>Plant</th>
<th>Location/origin</th>
<th>Site of alleles at STS loci (base pairs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primitivo</td>
<td>France/France</td>
<td>164-186</td>
</tr>
<tr>
<td>Primitivo</td>
<td>France/France</td>
<td>164-186</td>
</tr>
<tr>
<td>Primitivo</td>
<td>Italy/Italy</td>
<td>164-186</td>
</tr>
<tr>
<td>Primitivo di Giola</td>
<td>Australia/US</td>
<td>164-188</td>
</tr>
<tr>
<td>Zinfandel</td>
<td>Australia/US</td>
<td>164-188</td>
</tr>
<tr>
<td>Zinfandel</td>
<td>Australia/US</td>
<td>164-188</td>
</tr>
</tbody>
</table>

* Different names are synonyms for the cultivar Primitivo

Franks et al. 2001

4) Zinfandel Heritage Block at the Oakville station

- Initiated in 1996 by Jim Wolpert and UC Farm Advisors
- Department of Viticulture and Enology, UC Davis

Winemakers’ Complaints About Certified Zinfandel Clones

- Clusters are large, tight and rot-prone
- Berries are large
- Wines tend to have poor color and varietal character
- Conclusion: Good for “white” but not for “red”
Zinfandel Heritage Vineyard

Zinfandel Safari Scouts and Trailblazers

Amand Kasimatis  Rhonda Smith
Ed Weber  Janet Caprile
Paul Verdegaal  Jack Foott
Donna Hirschfelt  Glenn McGourty

- Counties represented:
  - Mendocino, Lake
  - Sonoma, Napa
  - El Dorado, Amador
  - Calaveras, San Joaquin
  - Santa Clara, Alameda
  - San Luis Obispo
  - Riverside and
  - San Bernardino
  - 90 collections from over
  - 100 vineyards!!
Zinfandel Heritage Vineyard

- Selected for
- 1) Small berries and loose clusters
- 2) Planted pre-1919
- 3) Free of virus

- Planted at Oakville Station
- onto St. George Rootstock
- in Randomized Complete Block Design (RBCD)

Oakville Station, Napa Valley, CA

Rep. 4 & 5
Rep. 1, 2 & 3
Zinfandel Heritage Vineyard, Phase 1

Table 1. Summary of polyene chain reaction analysis of the Zinfandel Heritage Vineyard, 1999.

<table>
<thead>
<tr>
<th>Virus</th>
<th>Linear</th>
<th>Labeled</th>
<th>for</th>
<th>Selections</th>
<th>Positive</th>
<th>Negative</th>
<th>% Positive</th>
<th>Total</th>
<th>any LA</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
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<td>6 7 8</td>
<td>9 10 11</td>
<td>12 13 14</td>
<td>15 16 17</td>
<td>18 19 20</td>
<td>21 22 23</td>
<td>24 25 26</td>
<td>27 28 29</td>
<td>30 31 32</td>
<td>33 34 35</td>
<td>36 37 38</td>
</tr>
</tbody>
</table>

Zinfandel Heritage Block Map, Phase 2

- [Image of Zinfandel Heritage Block Map, Phase 2]
5) Data from Oakville, Past & Present

Clones studied in 2013 for
1) Cluster Weight
2) Berry Weight
3) Berries/cluster
4) Seeds/ berry
5) Soluble solids
6) pH
7) Titratable acidity
8) Malic acidity
9) Yeast assimilable nitrogen
10) Pruning weights
11) Budbreak
12) HPLC-DAD Phenolic fingerprint

<table>
<thead>
<tr>
<th>Heritage ID</th>
<th>Designation</th>
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<tr>
<td>10</td>
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</tr>
<tr>
<td>30</td>
<td>UCD #2</td>
</tr>
<tr>
<td>31</td>
<td>Sonoma</td>
</tr>
<tr>
<td>40</td>
<td>UCD #4 (FPMS Primitivo 6)</td>
</tr>
<tr>
<td>55</td>
<td>Napa</td>
</tr>
<tr>
<td>79</td>
<td>San Josequin</td>
</tr>
<tr>
<td>80</td>
<td>Santa Clara</td>
</tr>
<tr>
<td>89</td>
<td>El Dorado</td>
</tr>
</tbody>
</table>

Cluster and Berry Weights, 2013

ANOVA
Df=7 P=0.0008*

Df=7 (P<0.01)

Df=7 (P=0.05)
Cluster Weights

- Heritage Clone 89
- El Dorado County

Heritage Clone 40
FPS Primitivo 03 ‘di Gioia’

Juice Analysis

- Soluble Solids, 2013
- Juice pH, 2013
- Yeast Assimilable Nitrogen, 2013
- Malic Acid, 2013
Pruning Weight and Budbreak

Pruning Weights, 2014

Budbreak score, 2014

HPLC-DAD Phenolic Statistical Analysis

Extraction according to Price et al. 1995, Buscema and Boulton 2015.

HPLC-DAD analysis according to Lamuela-Raventos and Waterhouse 1994, Ortega-Regules et al. 2006.
Clone 89?

Photos courtesy of Greg Boeger
Fossati-Lombardo vineyard planted in 1860’s
El Dorado county. Origin of planting material unknown.
Heritage Vineyard Data (2005-2009)


2. Berry Weight (2005-2009)


- Berry Weight vs. Clone Number
- Cluster Weight vs. Clone Number
- Brix vs. Clone Number
- Berries/cluster vs. Clone Number

Berries/Cluster, 2005-2013

Soluble Solids, 2005-2013
Sugar Accumulation and Crop Load


Conclusion

- **Primitivo** has lower cluster weights, less berries/cluster, and higher brix. Clone 89 had higher berries/cluster and lower brix only in 2013.
- Zinfandel selections do not express differences in a RBCD
- In agreement with Wolpert (1996), and Fidelibus et al. (2005)
- **Primitivo** may have less bunch rot (Fidelibus 2005), and may ripen earlier, however may lead to higher alcohol wines
- More genetic diversity could be found in Croatia. Or Montenegro? Maybe Hungary! Maybe even Germany!
Funding Provided By:

- Zinfandel Advocates & Producers
- American Vineyard Foundation
- Viticultural Research Scholarships
  - Pearl and Albert J. Winkler Scholarship
  - Leon D. Adams Research Scholarship
  - Curtis J Alley Memorial Research
  - Harold P. Olmo Scholarship
  - Wine Spectator Scholarship

Thank you

- Questions? Comments?

- Michael Penn
- M.S. Viticulture & Enology, 2015
- Walker Viticulture Lab
- mapenn@ucdavis.edu
References


