# COMPARISON OF CALIFORNIA HERITAGE ZINFANDEL AND PRIMITIVO GRAPEVINE SELECTIONS

## in Napa Valley, California

MARCH 19, 2015

MICHAEL PENN
M.S. VITICULTURE & ENOLOGY

UCDAVIS

## 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**

UCDAVIS
UNIVERSITY OF CALIFORNIA

## 2013 NASS California Acreage and Crush Report

| Crushed Tons (all reds) | Crushed Tons (Zinfandel) | Percent (Zinfandel) | Crushed Tons (Primitivo) | Percent (Primitivo) | |
|---|---|---|---|---|---|
| 2,416,378 | 469,215 (2nd for red) | 19.4% | 1,893 (24th) | 0.08% | |
| **Total Winegrape Acreage** | **Total Red Winegrape Acreage** | **Bearing Acres (Zinfandel)** | **Non-bearing Acres (Zinfandel)** | **Bearing Acres (Primitivo)** | **Non-bearing Acres (Primitivo)** |
| 494,192 | 308,698 | 47,624 (2nd) | 1,104 (5th) | 327 (21st) | 446 (7th) |
| **Wtd. Avg. $/ton (Zinfandel)** | **Gross Value (Zinfandel)** | | | | |
| $715.31 | $335,634,181.00 | | | | |

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Tons of Winegrapes Crushed in 2013 by District

| Grape Pricing District Number | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Chardonnay | 28,193 | 2,338 | 87,884 | 31,228 | 5,391 | 8,646 |
| Cabernet Sauvignon | 9,698 | 14,121 | 44,256 | 65,919 | 1,030 | 7,435 |
| Zinfandel | 6,932 | 3,040 | 20,172 | 5,338 | 566 | 3,295 |
| Merlot | 7,746 | 2,083 | 18,785 | 21,038 | 1,148 | 4,358 |
| French Colombard | 1,042 | 615 | 572 | 32 | 210 | 181 |
| Pinot Noir | 8,736 | 264 | 54,827 | 12,039 | 4,153 | 2,344 |
| Rubired | - | - | - | 6 | - | - |
| Pinot Gris | 600 | 663 | 2,789 | 677 | 2,998 | 1,088 |
| Syrah | 2,741 | 1,187 | 4,836 | 2,803 | 346 | 1,236 |
| Sauvignon Blanc | 4,240 | 13,066 | 19,388 | 18,010 | 1,012 | 1,671 |
| Muscat of Alexandria | - | - | 2 | - | - | 16 |

| Grape Pricing District Number | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|
| Chardonnay | 116,540 | 55,400 | 20,672 | 662 | 155,868 | 60,610 |
| Cabernet Sauvignon | 36,015 | 56,464 | 4,554 | 1,778 | 145,264 | 57,389 |
| Zinfandel | 555 | 11,596 | 10,692 | 8,835 | 178,895 | 24,473 |
| Merlot | 37,927 | 24,734 | 4,159 | 2,280 | 95,348 | 38,041 |
| French Colombard | 6,848 | 1,355 | 8 | 8 | 3,273 | 11,654 |
| Pinot Noir | 56,044 | 28,956 | 2,123 | 65 | 25,696 | 24,970 |
| Rubired | - | - | 764 | - | 621 | 5,544 |
| Pinot Gris | 8,123 | 3,654 | 3,108 | 157 | 49,064 | 33,657 |
| Syrah | 10,421 | 19,073 | 4,554 | 1,770 | 25,555 | 12,809 |
| Sauvignon Blanc | 10,432 | 7,069 | 1,202 | 630 | 23,674 | 5,126 |
| Muscat of Alexandria | - | - | 4,263 | 97 | 402 | 5,360 |

| Grape Pricing District Number | 13 | 14 | 15 | 16 | 17 | 2013 State Total |
|---|---|---|---|---|---|---|
| Chardonnay | 97,507 | 39,796 | 37 | 248 | 47,162 | 758,188 |
| Cabernet Sauvignon | 53,733 | 22,990 | 49 | 833 | 2,559 | 524,086 |
| Zinfandel | 152,661 | 37,658 | 197 | 284 | 4,027 | 469,216 |
| Merlot | 57,590 | 20,839 | 41 | 393 | 9,642 | 346,149 |
| French Colombard | 267,664 | 36,701 | - | - | - | 319,819 |
| Pinot Noir | 11,450 | 11,332 | 19 | 37 | 16,637 | 259,691 |
| Rubired | 196,417 | 52,281 | - | 6 | - | 255,640 |
| Pinot Gris | 32,281 | 24,357 | 2 | 104 | 15,565 | 178,887 |
| Syrah | 41,602 | 2,193 | 33 | 483 | 898 | 132,538 |
| Sauvignon Blanc | 3,333 | 3,282 | 7 | 152 | 15,364 | 127,655 |
| Muscat of Alexandria | 79,658 | 35,694 | 1 | 11 | 10 | 125,514 |

## 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)**

UCDAVIS
UNIVERSITY OF CALIFORNIA

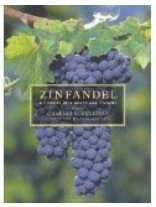
## Ampelography

- **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.



Bettiga, L. 2003. Winegrape Varieties in California. Univ. of California A&NR; 1st edition.

## Charles Sullivan




- **Professor of History, Los Gatos Community College**
- **Zinfandel: A history of a grape and its wine (2003)**
- **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**

UCDAVIS
UNIVERSITY OF CALIFORNIA

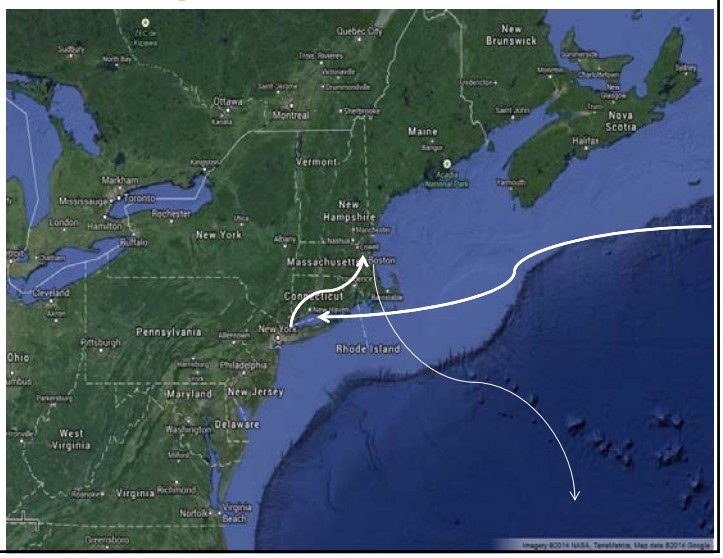
## ...Long Island, New England...

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



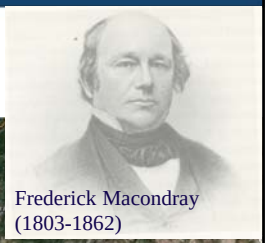
## …California Zinfandel

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

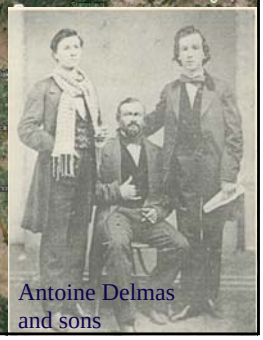
2) 1852, J.W. Osborne grafts over Oak Knoll vineyard to Zinfandel and other varieties from Macondray

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.

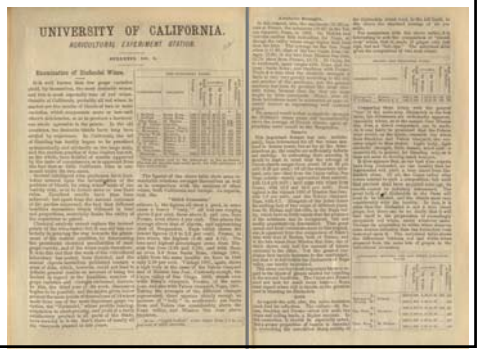
Frederick Macondray (1803-1862)



Antoine Delmas and sons

## 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."


UNIVERSITY OF CALIFORNIA.
AGRICULTURAL EXPERIMENT STATION.

UCDAVIS
UNIVERSITY OF CALIFORNIA

## George Hussman

- "Zinfandel, or Zinfindal, 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"

UCDAVIS UNIVERSITY OF CALIFORNIA

***- 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

325783. Col. No. 214. Along road from Quirequire to Caripito at Km. 12.
325784. Col. No. 215. Along road from Quirequire to Carupano north of Caripito, Km. 12.
From Sucre, Guiria.
325785. Col. No. 216. Along beach, south edge of town.
325786. Col. No. 217. Along beach, south edge of town.
325787. Col. No. 222. Along beach, south edge of town.
Behind beach coconuts, south edge of town.
325788. Col. No. 218.
325789. Col. No. 219.
325790. Col. No. 220.
325791. Col. No. 221.
325792. Col. No. 224.
325793. Col. No. 225.
325794. Col. No. 226. Foothills dooryard between Guiria and Rio Salado.
325795 to 325797. VITIS VINIFERA L. Vitaceae.
European grape.
From Italy. Cuttings presented by the Instituto di Patologia Vegetale, Bari. Received Feb. 19, 1968.
325795. 'Primitivo di Gioia No. 2'.
325796. 'Primitivo di Gioia No. 473'.
325797. 'Primitivo di Gioia No. 480'.
325798 to 325802. PUNICA GRANATUM L. Punicaceae.
Pomegranate.
From Sicily. Scions presented by the Universita Degli Studi di Catania, Instituto di Coltivazioni Arboree, Catania. Received Feb. 20, 1968.

- 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

UCDAVIS
UNIVERSITY OF CALIFORNIA

Franks et al. 2001

## Primitivo

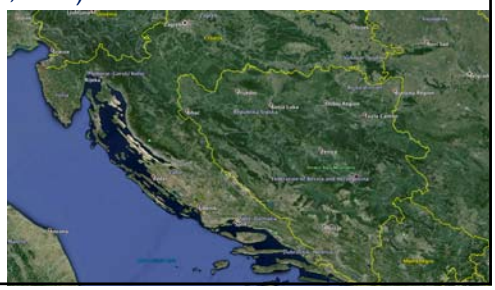
- Oldest historical note
- 1799, a priest named Francesco Filippo Indellicati (1767-1831) notes in the Gioia town records of his selection of an earlier ripening vine from among a population of Zagarese (from Zagreb).
- (Robinson et al., 2012)

Gioia del Colle

UCDAVIS
UNIVERSITY OF CALIFORNIA

## 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 Crljenak 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)



## Microsatellite Data

**Table 2** Microsatellite genotypes of Plavac mali and its presumptive parents Zinfandel and Dobrèiæ

| Locus | Zinfandel | Plavac mali | Dobrèiæ | Locus | Zinfandel | Plavac mali | Dobrèiæ |
|---|---|---|---|---|---|---|---|
| VVMD5 | 226, 236 | 226, 228 | 228, 228 | VrZAG62 | 201, 205 | 191, 205 | 191, 205 |
| VVMD6 | 212, 214 | 212, 212 | 212, 214 | VrZAG79 | 237, 259 | 237, 259 | 237, 259 |
| VVMD7 | 247, 249 | 247, 249 | 247, 249 | VrZAG83 | 191, 197 | 197, 197 | 191, 197 |
| VVMD21 | 243, 249 | 249, 258 | 249, 258 | VrZAG93 | 189, 215 | 189, 215 | 189, 215 |
| VVMD24 | 210, 210 | 210, 214 | 214, 219 | VMC2C3 | 165, 192 | 165, 192 | 165, 179 |
| VVMD25 | 243, 243 | 243, 245 | 243, 245 | VMC5G6.1 | 139, 155 | 142, 155 | 142, 142 |
| VVMD26 | 249, 251 | 251, 251 | 251, 251 | VMC2H4 | 224, 228 | 224, 224 | 224, 224 |
| VVMD27 | 179, 181 | 179, 179 | 179, 179 | VMC5A1 | 170, 172 | 162, 172 | 162, 162 |
| VVMD28 | 251, 261 | 251, 261 | 251, 261 | VMC5H2 | 197, 213 | 194, 197 | 194, 194 |
| VVMD31 | 212, 214 | 212, 212 | 212, 216 | VMC2B3 | 166, 166 | 166, 188 | 166, 188 |
| VVMD32 | 257, 265 | 253, 257 | 253, 265 | VMC5H5 | 176, 178 | 176, 176 | 172, 176 |
| VVMD36 | 254, 254 | 254, 270 | 254, 270 | VMC5C1 | 146, 174 | 146, 146 | 146, 146 |
| VVS2 | 133, 143 | 143, 145 | 145, 151 | | | | |

Am. J. Enol. Vitic. 55:2 (2004)

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

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Microsatellite Data

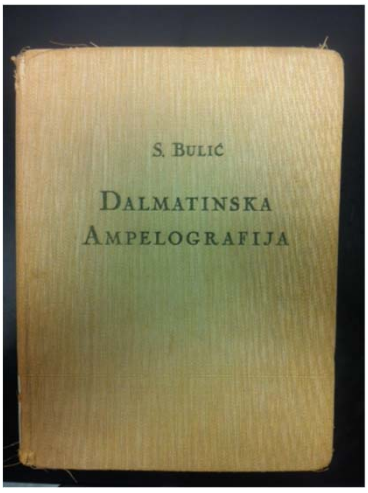
**Table 2** SSR profiles of 15 individual varieties (allele lengths in bp).

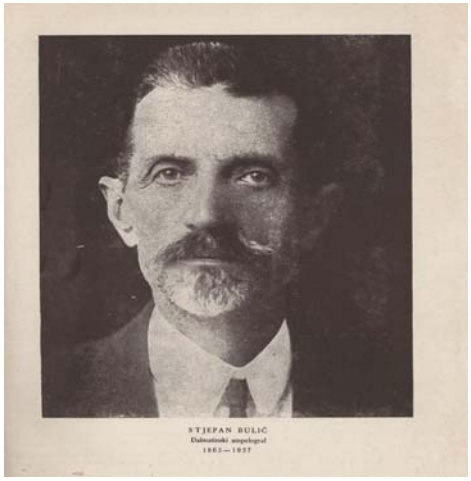
| SSR loci | Crljenak Kaštelanski Kratošija Primitivo Zinfandel | Dobričić | Dolcetto | Franconia | Furmint | Harzevelu | Hrvatica | Jarbola bijela | Kadarka | Pignola | Plavac mali | Plavina | Riesling italico | Vettliner frührot | Vranac |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VVS2 | 133 | 145 | 139 | 143 | 133 | 133 | 151 | 143 | 133 | 155 | 143 | 133 | 135 | 133 | 133 |
| | 143 | 151 | 143 | 143 | 153 | 145 | 153 | 155 | 135 | 155 | 145 | 143 | 151 | 151 | 133 |
| VVMD5 | 226 | 228 | 234 | 226 | 226 | 226 | 226 | 236 | 226 | 232 | 226 | 232 | 226 | 232 | 226 |
| | 236 | 228 | 246 | 240 | 240 | 232 | 238 | 240 | 226 | 236 | 228 | 236 | 238 | 240 | 226 |
| VVMD7 | 247 | 247 | 247 | 239 | 239 | 239 | 239 | 247 | 247 | 253 | 247 | 239 | 247 | 247 | 247 |
| | 249 | 249 | 255 | 249 | 249 | 247 | 247 | 249 | 255 | 263 | 249 | 249 | 257 | 253 | 249 |
| VVMD27 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 179 | 185 | 181 | 179 | 179 | 185 | 189 | 181 |
| | 181 | 179 | 194 | 194 | 194 | 179 | 179 | 181 | 194 | 189 | 179 | 189 | 189 | 194 | 181 |
| VVMD28 | 251 | 251 | 231 | 249 | 231 | 231 | 257 | 239 | 231 | 237 | 251 | 251 | 249 | 239 | 239 |
| | 261 | 261 | 237 | 249 | 251 | 251 | 281 | 249 | 263 | 239 | 261 | 261 | 261 | 271 | 251 |
| VVMD32 | 257 | 253 | 263 | 251 | 265 | 265 | 251 | 251 | 273 | 241 | 253 | 253 | 241 | 265 | 257 |
| | 265 | 265 | 273 | 273 | 273 | 273 | 253 | 273 | 273 | 263 | 257 | 265 | 273 | 273 | 257 |
| VVMD36 | 254 | 254 | 252 | 264 | 254 | 264 | 254 | 248 | 266 | 244 | 254 | 254 | 254 | 264 | 254 |
| | 254 | 270 | 264 | 266 | 276 | 276 | 264 | 264 | 276 | 296 | 270 | 270 | 264 | 264 | 254 |
| VrZAG 62 | 199 | 189 | 203 | 193 | 187 | 187 | 187 | 201 | 187 | 193 | 189 | 187 | 193 | 191 | 193 |
| | 203 | 203 | 203 | 203 | 203 | 203 | 203 | 203 | 203 | 193 | 203 | 199 | 195 | 203 | 199 |
| VrZAG 79 | 236 | 236 | 248 | 236 | 236 | 236 | 250 | 242 | 248 | 250 | 236 | 236 | 250 | 250 | 258 |
| | 258 | 258 | 250 | 250 | 248 | 250 | 250 | 258 | 250 | 258 | 258 | 242 | 250 | 250 | 258 |
| ISV2 | 141 | 141 | 141 | 165 | 165 | 161 | 151 | 143 | 141 | 159 | 143 | 143 | 151 | 151 | 151 |
| (VMC 6e1) | 165 | 143 | 143 | 169 | 165 | 165 | 165 | 165 | 165 | 165 | 165 | 165 | 161 | 165 | 165 |
| ISV3 | 139 | 131 | 133 | 135 | 131 | 139 | 133 | 133 | 133 | 135 | 133 | 139 | 139 | 133 | 133 |
| (VMC 6f1) | 139 | 139 | 145 | 139 | 139 | 141 | 139 | 139 | 139 | 139 | 139 | 139 | 139 | 139 | 139 |
| ISV4 | 177 | 187 | 177 | 177 | 193 | 177 | 177 | 177 | 187 | 169 | 177 | 177 | 169 | 169 | 177 |
| (VMC 6g1) | 177 | 197 | 187 | 197 | 197 | 197 | 187 | 197 | 193 | 177 | 187 | 177 | 169 | 187 | 177 |
| VMCNG4b9 | 150 | 138 | 162 | 138 | 138 | 138 | 158 | 158 | 176 | 162 | 150 | 150 | 150 | 150 | 164 |
| | 164 | 164 | 166 | 158 | 158 | 152 | 172 | 166 | 176 | 178 | 164 | 152 | 168 | 158 | 172 |

Calo et al., 2008. Am. J. Enol. Vitic. 59:2

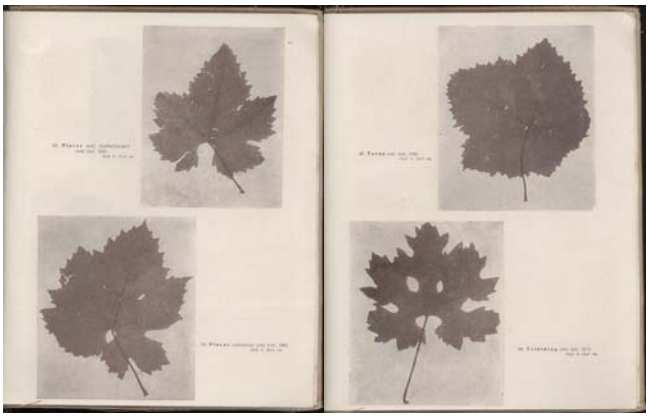
UCDAVIS
UNIVERSITY OF CALIFORNIA

## Stjefan Bulic (1865-1937)
## Croatian Ampelographer



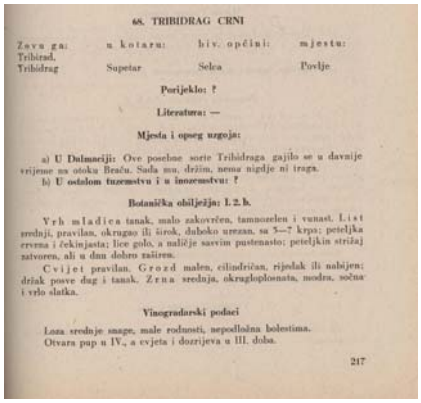



## Croatian Ampelography



UCDAVIS
UNIVERSITY OF CALIFORNIA

## Croatian Ampelography



68. TRIBIDRAG CRNI

Zove ga: u kotaru: biv. općini: mjestu:
Tribirad, Tribidrag — Supetar — Selca — Povlje

Porijeklo: ?

Literatura: —

Mjesta i opseg uzgoja:

a) U Dalmaciji: Ove posebne sorte Tribidraga gajilo se u davnije vrijeme na otoku Braču. Sada nu, držim, nemu nigdje ni traga.
b) U ostalom tuzemstvu i u inozemstvu: ?

Botanička obilježja: I. 2. b.

Vrh mladica tanak, malo zakovrčen, tamnozelen i vunast. List srednji, pravilan, okrugao ili širok, duboko urezan, sa 5—7 krpa; peteljka crvena i čekinjasta; lice golo, a naličje savim pustenasto; peteljkin strižaj zatvoren, ali u dnu dobro razvren.

Cvijet pravilan. Grozd malen, cilindričan, rijedak ili nabijen; držak posve dug i tanak. Zrno srednja, okrugloploosnata, modra, sočna i vrlo slatka.

Vinogradarski podaci

Loza srednje snage, male rodnosti, nepodložna bolestima.
Otvara pup u IV., a cvjeta i dozrijeva u III. doba.

217

UCDAVIS
UNIVERSITY OF CALIFORNIA

**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 Characeristics:**
Top of shoots are thin, slightly curly, dark green and wooly. 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 vignerons

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Mechanisms to clonal polymorphisms

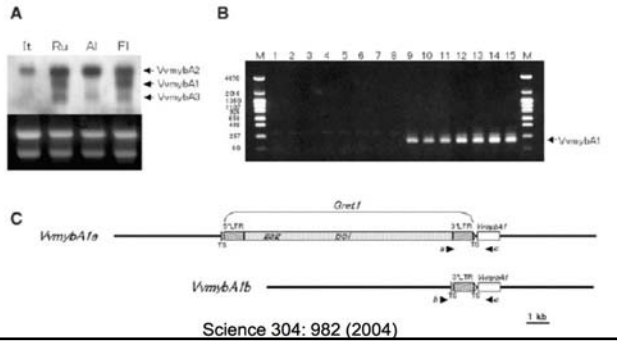
- Variegation
  - Defective plastids, mutations in chloroplasts and mitochondria
- Transposons
  - Many in grapes (41% of genome), gret1for color
- Somaclonal variation
  - Most common in grapevines. Genetic mutations
- Epigenetic modifications
  - DNA methylation…???
- Viruses and viroids
- (Pelsy et al. 2010)

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Tranposons

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

Expression of UFGT 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.




Science 304: 982 (2004)

UCDAVIS
UNIVERSITY OF CALIFORNIA

## 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

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Somaclonal Mutations

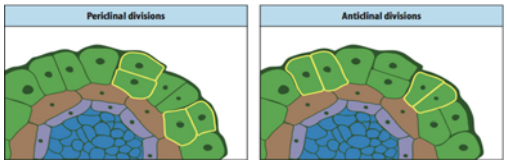
- Rare…but they happen.
- 1) Slippage of DNA polymerase
  - Exons account for 6.9% of grapevine genome!
- 2) Mutation in shoot meristem cell
- 3) Periclinal growth of mutated cell to become distinct cell layer
- 4) Periclinal chimera must survive annual pruning
- 5) Must be selected for vegetative propagation

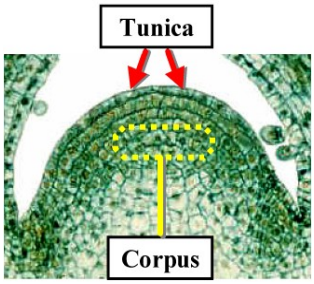
UCDAVIS UNIVERSITY OF CALIFORNIA

(Hocquigny et al. 2004)

## Shoot Apical Meristem

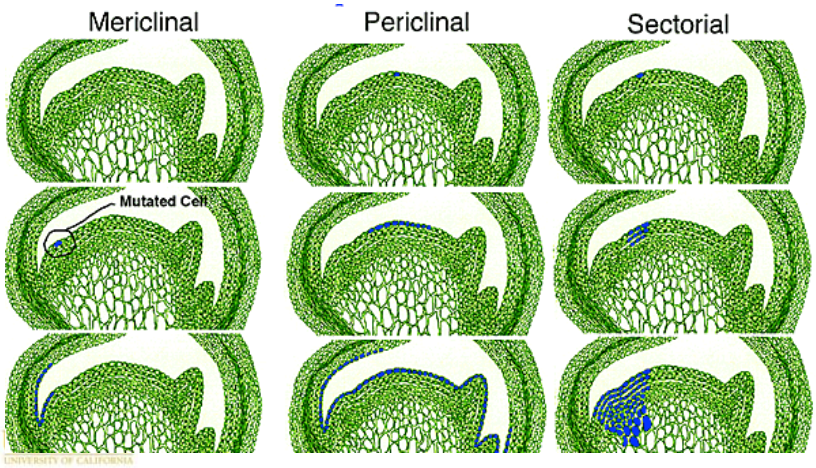
- Tunica corpus meristem
- Tunica- outside layer of cells
- Corpus- unlayered structure
- L1 (outer) grows periclinal (perpendicular to suface)
- L2 (middle) grows anticlinal, then periclinal




UCDAVIS UNIVERSITY OF CALIFORNIA

## Plant Chimera

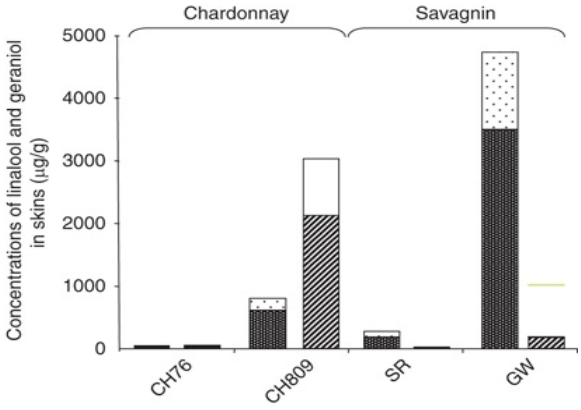



## What would we expect to be different in a clone?

- **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)**

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Aroma variation




UCDAVIS UNIVERSITY OF CALIFORNIA

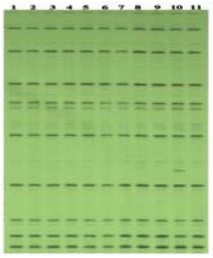
(Duchene et al. 2009)

## 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)**

UCDAVIS UNIVERSITY OF CALIFORNIA

## Genetic Variation of Zinfandel/Primitivo/Tribidrag



- AFLP profiles for one primer combination EcoRI (ACT)-MseI (CAG). Genotypes from left to right: (1) Primitivo-Ba.I 21, (2) Primitivo-Ba.II P6 F1, (3) Primitivo-Ma. 7, (4) Primitivo-Ve.I P16, (5) Primitivo-Ba.II P2 H3, (6) Primitivo-Ma.P24 C2, (7) Primitivo-Mu. 13, (8) Zinfandel, (9) Crljenak kastelanski, (10) Primitivo-Pi. 1, (11) Primitivo-Pa. V.
- Vitis **44** (3), 147–148 (2005)

**Table 1** DNA profiles of Primitivo plants

| Plant[a] | Location/origin[b] | Size of alleles at STS loci (base pairs) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | VVS19 | VVS1 | VVS2 | VVS29 | VVS5 | VVS16 | VVMD7 |
| Primitivo | France/France | 164:186 | 188:190 | 134:144 | 171:179 | 148:– | 286:– | 247:249 |
| Primitivo | France/France | 164:186 | 188:190 | 134:144 | 171:179 | 148:– | 286:– | 247:249 |
| Primitivo | Italy/Italy | 164:186 | 188:190 | 134:144 | 171:179 | 148:– | 286:– | 247:249 |
| Primitivo di Gioia | Australia/US | 164:186:188 | 188:190 | 134:144 | 171:179 | 148:– | 286:– | 247:249 |
| Zinfandel | Australia/US | 164:186 | 188:190 | 134:144 | 171:179 | 148:– | 286:– | 247:249 |
| Zinfandel | Australia/US | 164:186 | 188:190 | 134:144 | 171:179 | 148:– | 286:– | 247:249 |

[a] Different names are synonyms for the cultivar Primitivo

[b] Location plant is grown at the country indicated, whereas the origin of the plant is traced back as far as possible from limited germplasm records. US=United States

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"

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Zinfandel Heritage Vineyard

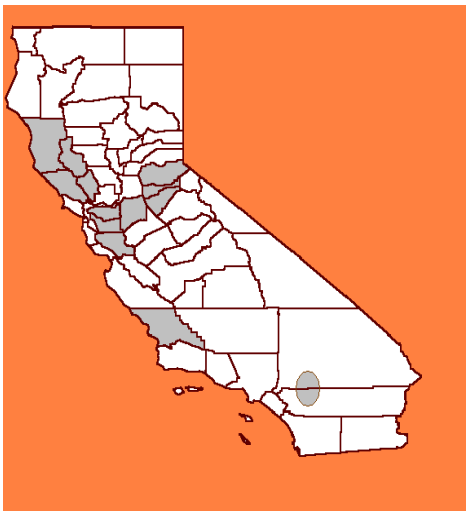
Zinfandel Safari Scouts and Trailblazers

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

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Zinfandel Heritage Vineyard

- 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!!



UCDAVIS
UNIVERSITY OF CALIFORNIA

## 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)

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Oakville Station, Napa Valley, CA

## Zinfandel Heritage Vineyard, Phase 1

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

| | Virus | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leafroll tested for | | | | | | | | | | | |
| | 1,2,7 | 3 | 4,5 | 5 | GVA | GVB | GVD | GFLV | ArMV | RG | TobRSV | TmRSV |
| selections positive | 11 | 5 | 23 | 0 | 6 | 8 | 1 | 0 | 0 | 0 | 0 | 0 |
| selections negative | 68 | 74 | 56 | 79 | 73 | 71 | 78 | 79 | 79 | 79 | 79 | 79 |
| % positive | 14 | 6 | 29 | 0 | 8 | 10 | 1 | 0 | 0 | 0 | 0 | 0 |
| | | | | Total any LR virus | | | | | | | | Total any virus |
| | | | selections | 36 | | | | | | | | 37 |
| | | | selections | 43 | | | | | | | | 42 |
| | positiv | | | 46 | | | | | | | | 47 |

GLRaV127 = grapevine leafroll associated virus types 1, 2, and 7 (used universal primers)
GLRaV3 = grapevine leafroll associated virus type 3
GLRaV45 = grapevine leafroll associated virus types 4 and 5 (used universal primers)
GLRaV5 = grapevine leafroll associated virus type 5
GVA= grapevine virus A (causal agent of Kober stem grooving)
GVB = grapevine virus B (causal agent of corky bark)
GVD = grapevine virus D (causal agent of corky bark??)
GFLV = grapevine fanleaf virus
ArMV = arabis mosaic virus (a quarantine nepovirus)
RSP = grapevine rupestris stem pitting associated virus
RG = a new virus isolated from Redglobe table grape (in leafroll virus group)
TobRSV = tobacco ringspot virus
TmRSV = tomato ringspot virus (causal agent of grapevine yellow vein virus)

## Zinfandel Heritage Block Map, Phase 2

Zinfandel Expansion Block
St. Geo. Rootstock planted 7/21-7/23/2001, Budded 5/22-5/24/02
NOTE: SELECTION 81 TO BE FALL BUDDED 9/02
7'10.2" x 6' RxV

| | R1-4 | R5-7 | R8-10 | R11-13 | R14-16 | R17-19 | R20-22 | R23-25 | R26-28 | R29-31 | R32-35 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| V32-40 | Zin #23 | Zin #42 | Zin #72 | Zin #19 | Zin #50 | Zin #1 | Zin #33 | Zin #31 | Zin #50 | Zin #38 | Zin #10 |
| V26-31 | Zin #19 | Zin #40 | Zin #55 | Zin #53 | Zin #16 | Zin #80 | Zin #10 | Zin #80 | Zin #1 | Zin #30 | Zin #81 |
| V20-25 | Zin #16 | Zin #38 | Zin #53 | Zin #89 | Zin #30 | Zin #31 | Zin #44 | Zin #19 | Zin #55 | Zin #79 | Zin #40 |
| V14-19 | Zin #13 | Zin #33 | Zin #50 | Zin #79 | Zin #13 | Zin #40 | Zin #79 | Zin #42 | Zin #89 | Zin #13 | Zin #53 |
| V8-13 | Zin #10 | Zin #31 | Zin #48 | Zin #81 | Zin #81 | Zin #48 | Zin #55 | Zin #72 | Zin #44 | Zin #72 | Zin #23 |
| V1-7 | Zin #1 | Zin #30 | Zin #44 | Zin #80 | Zin #38 | Zin #89 | Zin #23 | Zin #42 | Zin #16 | Zin #33 | Zin #48 |
| | Rep 1 | | | | Rep 2 | | | | Rep3 | | |
| Avenue | | | | | | | | | | | |
| | Rep 4 | | | | | | Rep 5 | | | | |
| V1-7 | Zin #89 | Zin #44 | Zin #38 | Zin #1 | Zin #30 | Zin #81 | Zin#31 | Zin #23 | Zin #89 | Zin #42 | Zin #1 |
| V8-13 | Zin #50 | Zin #1 | Zin #55 | Zin #31 | Zin #48 | Zin #16 | Zin #48 | Zin #80 | Zin #10 | Zin #53 | Zin #33 |
| V14-19 | Zin #33 | Zin #72 | Zin #19 | Zin #42 | Zin #80 | Zin #40 | Zin #13 | Zin #81 | Zin #50 | Zin #30 | Zin #79 |
| V20-26 | Zin #23 | Zin #40 | Zin #79 | Zin #53 | Zin #10 | Zin #55 | Zin #19 | Zin #44 | Zin #38 | Zin #72 | Zin #16 |

UCDAVIS
UNIVERSITY OF CALIFORNIA

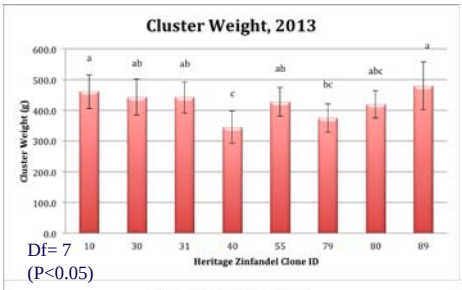
## 5) Data from Oakville, Past & Present

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

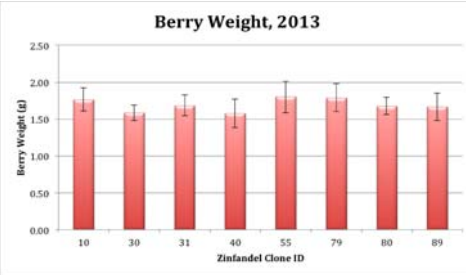
UCDAVIS
UNIVERSITY OF CALIFORNIA

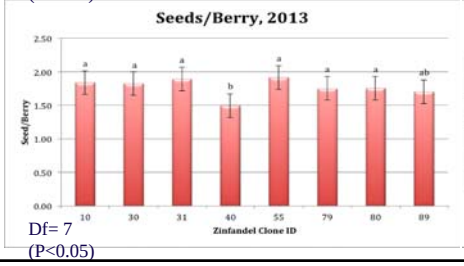
| Heritage ID # | Designation |
|---|---|
| 10 | Sonoma |
| 30 | UCD #2 |
| 31 | Sonoma |
| 40 | UCD # 4 (FPMS Primitivo 6) |
| 55 | Napa |
| 79 | San Joaquin |
| 80 | Santa Clara |
| 89 | El Dorado |

## Cluster and Berry Weights, 2013

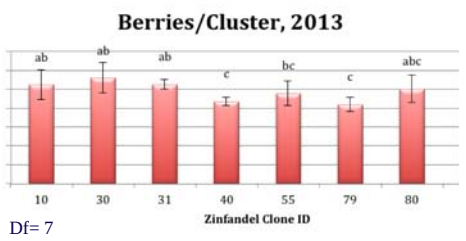



Df= 7
(P<0.05)




Df= 7
(P<0.05)




Df= 7
(P<0.01)

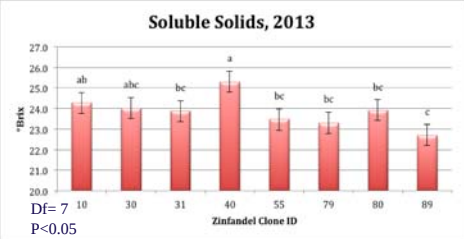
## Cluster Weights

Heritage Clone 89
El Dorado County

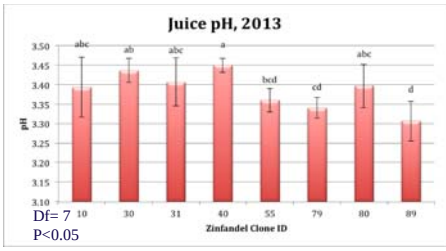
Heritage Clone 40
FPS Primitivo 03 ‘di Gioia’

UCDAVIS
UNIVERSITY OF CALIFORNIA

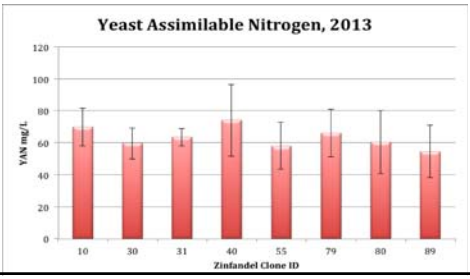
## Juice Analysis

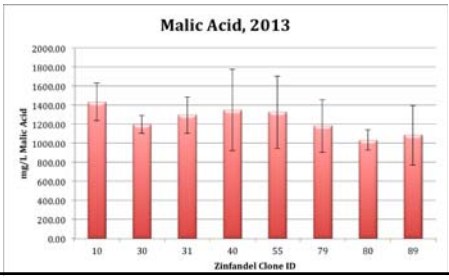



Df= 7
P<0.05

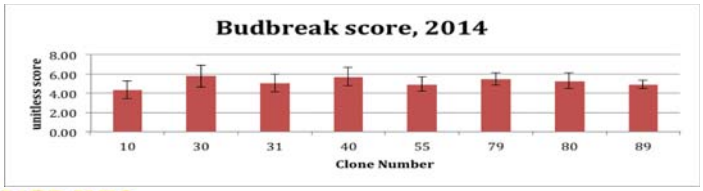



Df= 7
P<0.05



## Pruning Weight and Budbreak

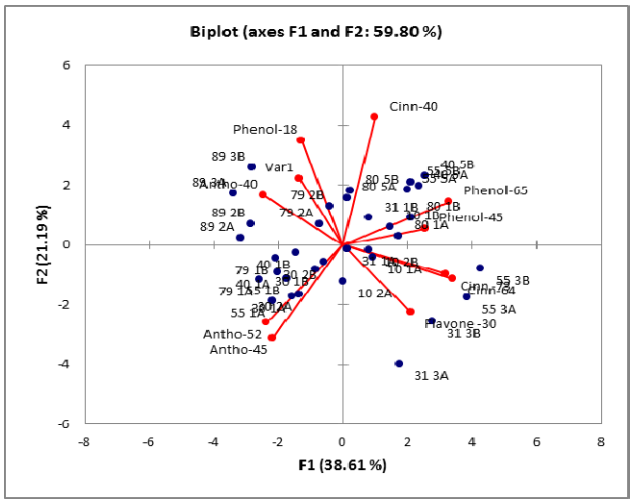




UCDAVIS
UNIVERSITY OF CALIFORNIA

## HPLC-DAD Phenolic Statistical Analysis

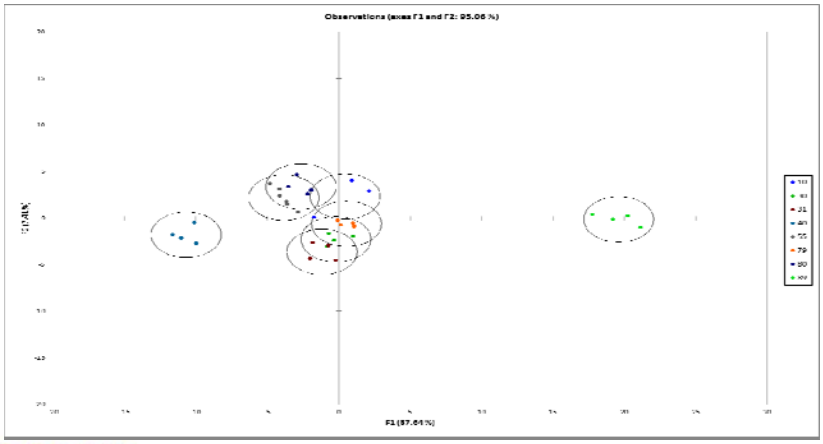
Extraction according to Price et al. 1995, Buscema and Boulton 2015.

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




UCDAVIS
UNIVERSITY OF CALIFORNIA

## HPLC-DAD Phenolic Statistical Analysis



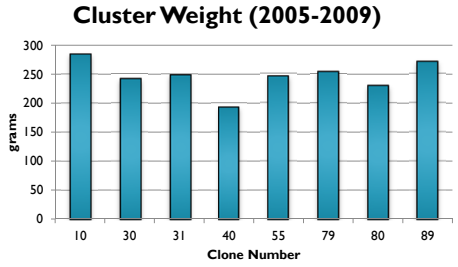
UCDAVIS
UNIVERSITY OF CALIFORNIA

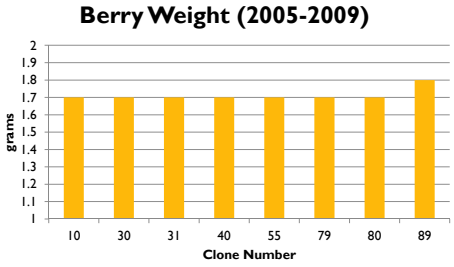
## Clone 89?

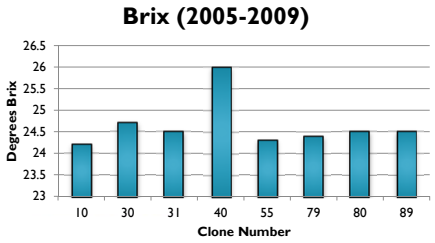
Photos courtesy of Greg Boeger
Fossati-Lombardo vineyard planted in 1860's
El Dorado county. Origin of planting material unknown.

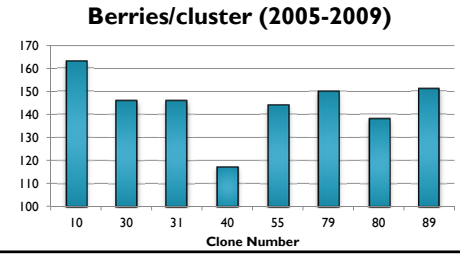
UCDAVIS
UNIVERSITY OF CALIFORNIA

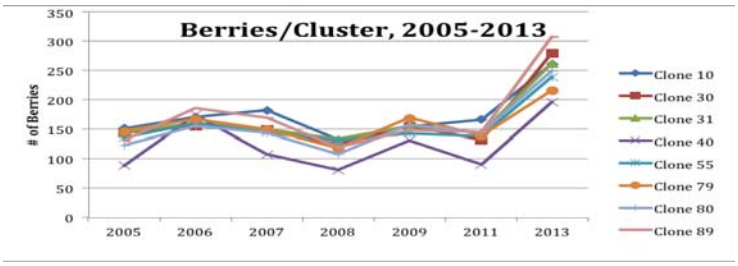
## Heritage Vineyard Data (2005-2009)

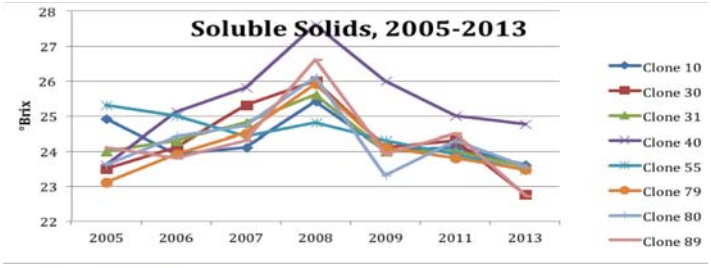


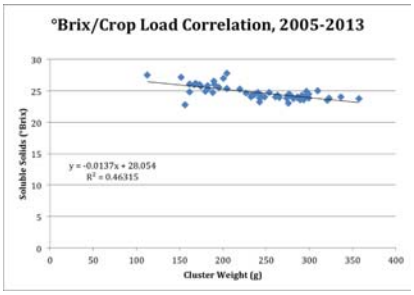



## Sugar Accumulation and Crop Load




Trend supports numerous studies that show correlation of yield with degrees brix

(Anderson et al. 2008, Barillere et al. 1995, Blazer et al. 1995, Boidron 1995, Nuzzo and Matthews 2006, Fidelibus 2005, Verdegaal and Rous 1995, Winkler 1931, Wolpert 1996)

UCDAVIS
UNIVERSITY OF CALIFORNIA

## 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!**

UCDAVIS
UNIVERSITY OF CALIFORNIA

## Funding Provided By:

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

UCDAVIS

V&E Viticulture & Enology UNIVERSITY OF CALIFORNIA DAVIS

## Thank you

- Questions? Comments?


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


UCDAVIS

## References


- Amerine, M. A., and A. E. Borg. 1996. A bibliography on grapes, wines, other alcoholic beverages, and temperance. Works published in the United States before 1901. Berkeley: University of California Press.
- Amerine, M. A., and A. E. Borg. 1996. A bibliography on grapes, wines, other alcoholic beverages, and temperance. Works published in the United States before 1901. Berkeley: University of California Press.
- Anderson, M.M., R.J. Smith, M.A. Williams, and J.A. Wolpert. 2008. Viticultural evaluation of French and California Pinot noir clones grown for production of sparkling wine. Am. J. Enol. Vitic. 59: 188–193.
- Barillere, J.M., A. Collas, C. Bougerey, and C. Palgé. 1995. Clonal selection in Champagne. *In* Proceedings of the International Symposium on Clonal Selection. J.M. Rantz (ed.), pp.33-39. American Society for Enology and Viticulture, Davis, CA.
- Blazer, R., and D. Roberts. 1995. Comparison of viticultural and enological characteristics of two Petit Verdot selections. *In* Proceedings of the International Symposium on Clonal Selection. J.M. Rantz (ed.), pp. 96-98. American Society for Enology and Viticulture, Davis, CA.
- Boidron, R. 1995. Clonal selection in France. Methods, organization, and use. *In* Proceedings of the International Symposium on Clonal Selection. J.M. Rantz (ed.), pp. 1-7. American Society for Enology and Viticulture, Davis, CA.
- Bowers, J.E., E.B. Bandman, and C.P. Meredith. 1993. DNA fingerprint characterization of some wine grape cultivars. Am. J. Enol. Vitic. 44: 266-274.
- Bulić, S. 1949. Dalmatinska ampelografija. Poljoprivredni nakladni zavod, Zagreb, Croatia.
- Buscema, F., and R.B. Boulton. 2015. Phenolic composition of Malbec: a comparative study of research-scale wines between Argentina and the United States. Am. J. Enol. Vitic. 66: 30-36
- California Grape Acreage Report (2013) and California Grape Crush Report (2013). California Agricultural Statistics Service, Sacramento, California. www.nass.usda.gov/Statistics_by_State/California/Publications/Grape_Crush/Reports.
- Calo, A., A. Costacurta, V. Maras, S. Meneghetti, and M. Crespan. 2008. Molecular correlation of Zinfandel with ınd Hungarian cultivars and Kratosija, an additional synonym. Am. J. Enol. Vitic. 59: 205-
- Duchene, E., J.L. Legras, F. Karst, D. Merdinoglu, P. Claudel, N. Jaegli, and F. Pelsy. 2009. Variation of linalool and geraniol content within two pairs of aromatic and non-aromatic grapevine clones. Aust. J. Grape Wine Res. 15: 120-130.
- Fidelibus, M.W., L.P. Christensen, D.G. Katayama, and P-T. Verdenal. 2005. Performance of Zinfandel and Primitivo grapevine selections in the central San Joaquin Valley, California. Am. J. Enol. Vitic. 56: 284-286.
- Franks, T., R. Botta, and M.R. Thomas. 2002. Chimerism in grapevines: implications for cultivar identity, ancestry, and genetic improvement. Theor. Appl. Genet. 104: 192-199.
- Hilgard, E. 1884. Examination of Zinfandel wines. Agric. Exper. Sta. Bull. No. 9:11-13.
- Hocquigny, S., F. Pelsy, V. Dumas, S. Kindt,, M-C. Heloir, and D. Merdinoglu. 2004. Diversification within grapevine cultivars goes through chimeric states. Genome 47, 579-589.
- Hussman, G. 1888. Grape Culture and Wine-making in California: a Practical Manual for the Grape-grower and Wine-maker. Payot, Upham & Co., San Francisco.
- Jaillon, O., et al. 2007. The grapevine genome sequence suggests ancestral hexaploidization in major angiosperm phyla. Nature. 449:463-467.
- Jung, A. 2007. Zinfandel, the story continues: new insights to its ancient variety history from a German point of view. Riv. Vitic. Enol. 3:37-68.
- Kobayashi, S., N. Goto-Yamamoto, and H. Hirochika. 2004. Retrotransposon-induced mutations in grape skin color. Science 304: 982.
- Kliewer, W.M., and N.K. Dokoozlian. Leaf area/crop weight ratios of grapevines: Influence on fruit composition and wine quality. Am. J. Enol. Vitic. 56: 170-181.
- Noble, A.C., and M. Shannon. 1987. Profiling Zinfandel wines by sensory and chemical analyses. Am. J. Enol. Vitic. 38: 1-5.
- Nuzzo, V., and M.A. Matthews. 2006. Response of fruit growth and ripening to crop level in dry-farmed Cabernet Sauvignon on four rootstocks. Am. J. Enol. and Vitic. 57: 314-324.
- Pelsy, F. 2010. Molecular and cellular mechanism of diversity within grapevines. Heredity 104: 331-340.
- Piljac, J. 2004. *Zinfandel: A Croatian-American Wine Story*. Zrinski d.d. Cakovec, Croatia.
- Robinson, J., Harding, J., and J. Vouillamoz. 2012. Wine Grapes. HarperCollins: China.
- Sullivan, C. L. 2003. *Zinfandel: A History of a Grape and Its Wine*. University of California Press. Berkeley, Los Angeles, London.
- Verdegaal, P.S., and C. Rous. 1995. Evaluation of five Zinfandel clones and one Primitivo clone for red wine in the Lodi appellation of California. *In* Proceedings of the International Symposium on Clonal Selection. J.M. Rantz (ed.), pp. 153- 156. American Society for Enology and Viticulture, Davis, CA.
- Winkler, A.J. 1931. Pruning and thinning experiments with grapes. Agric. Exper. Sta. Bull. No. 519.
- Wolpert, J.A. 1996. Performance of Zinfandel and Primitivo clones in a warm climate. Am. J. Enol. Vitic. 47:124-126