

Transition to Mechanical Harvest

FIELD DAY 8-17-17



With Dick Cooper, Cooper Vineyards Owner/Grower
Dr. Kaan Kurtural, UC Davis Viticulture Specialist
Sponsored by Lynn Wunderlich, UCCE Farm Advisor

Slides courtesy of Kaan Kurtural

Mechanized Harvest



- Grower control of peak ripeness due to speed
- Trellis set up
- Vineyard rows must be correctly spaced
- Logistics
 - Shipping times
- Materials Other than Grapes (MOG)

Economics of Harvest

UC Cost Studies <https://coststudies.ucdavis.edu/>

Hand Harvest (2015 Foothill Cost Study)

- **Harvest.** “In this study the owner uses the vineyard manager’s crew for harvest. The owner is charged \$140 per ton for picking and leafing (removing leaves from the bin). An additional \$20 per ton is charged to prep the field for harvest and \$30 per ton to swamp and load the crop. A \$40 per ton hauling charge is assumed to a local winery (within the county).”

Mechanical Harvest (2016 Sonoma Cost Study and 2016 Lodi Cost Study)

- **Sonoma Harvest.** “The vineyard management company machine harvests the Chardonnay block at a rate of \$115 per ton. The Pinot noir block is hand harvested at a rate of \$300 per ton. It is assumed that the grapes are delivered to a winery within the county and the hauling cost is included in the harvest cost.”
- **Lodi Harvest.** “The crop is machine harvested by a custom operator and costs \$350 per acre (@ 10 tons/ac). Hauling to the winery/crusher is contracted and the grower pays \$18 per ton for local hauls.”

Types of Harvesters

- **Tractor-drawn**
 - Cheapest alternative
 - Requires a tractor to pull and supply power via PTO
 - Some have hydrostatic drive “assist” for hill climbing
 - Addition of one more laborer to drive the harvester
- **Self-propelled**
 - Initial capital cost is high (>\$ 130,000)
 - Can harvest over 245 acres in a season
 - Larger capacity
 - Custom harvest as a sideline business
- **Multi-function self-propelled machines**
 - A range of tasks
 - Spraying
 - Pruning
 - Thinning
 - Harvesting
 - Have to purchase the attachments



Harvester brands and components

Modern Grape Harvester Brands

- Oxbo-Korvan™ (USA)
- American Grape Harvester (USA)
- URM (Australia)
- Nairn (New Zealand)
- Gregoire (France)
- Pellenc (France)
- Braud/New Holland (Europe)

Major Components of a Grape Harvester

- Chassis / Power Unit
- Picking System
- Catching System
- Conveying System
- Cleaning System



Chassis / Power Unit Comparison

- Self-Propelled
 - Advantages:
 - Maneuverability
 - Stability (in most situations)
 - Ease of Operation
 - Less vine damage
 - Less trellis damage
 - Disadvantages:
 - Higher initial cost
 - Fixed hp
 - Power unit not easily substituted
- Tow Behind
 - Advantages:
 - Select power unit hp based on situation
 - Safer to use on extreme slopes and side-hills
 - Lower initial cost
 - Power unit easily substituted
 - Disadvantages:
 - Tend to “duck-walk”
 - Tend to cause more vine and trellis damage
 - More difficult to operate

Methods Employed in Harvest

- Pivotal Strikers
 - Double bank of flexible horizontal rods that strike and shake the vine and remove the fruit
- Trunk Shakers
 - Two parallel skis set on edge that alternate from side to side and imparts horizontal vibration
 - Only effective removing fruit located close to a rigid trunk or cordon
 - Less MOG
 - Mostly for Cordon Trained Vines
 - Quad systems



Trunk Shaker System



Methods Employed in Harvest

- Bow-head or Bow-Rod units
 - Shaking elements are round plastic bars (1 to 1.5 “ in diameter) and 5-ft long
 - Horizontally oriented bars that move transversally and shake the vine
 - Shaking of the canopy in gentler than pivotal strikers and longer striking distance results in less leaves
 - Greater speeds than any other methods in harvest



Picking System: Bow Rod Head

- Extruded and formed 1.0" dia. nylon rods
- Steel, aluminum, or UHMW rod holders
- Adjustments:
 - Stroke (4-8")
 - Rod spacing (2.5-8")
 - Rod tension (firm)
 - Throat width (best fit)
 - RPM (300-450)
 - Forward speed (1.0-3mph)



Catching System

- Lexan or Nylon catcher plates
- Designed like flower petals or overlapping leaves
- Continuous overlap from front to rear and side to side
- Plates open and close only as needed to work around vine trunks and trellis posts
- Uni-directional – YOU CANNOT BACK UP!!!



How the Grapes Move to the Top

- Two schools of thought
- Bucket System
 - Moving buckets gently convey grapes
 - Reduced juicing
 - Only suitable in low tonnage situations (speed)
- Belt System
 - Closed horizontal Belt Convection Systems
 - Better in High Tonnage situations
 - However more damage to the berries/juicing

Bucket Conveying System

- High impact plastic buckets
- Attached to roller chains and hydraulically driven
- Fruit is carried in an almost static state
 - No dragging
 - No rolling
 - No unnecessary dumping
- Probably half of all harvesters have bucket lines, other half have flat or cleated belting



Points of Consideration

- Automatic transmissions?
- Adjustable picking heads?
- Discharge options?
- Auto-leveling?
- MOG removers?

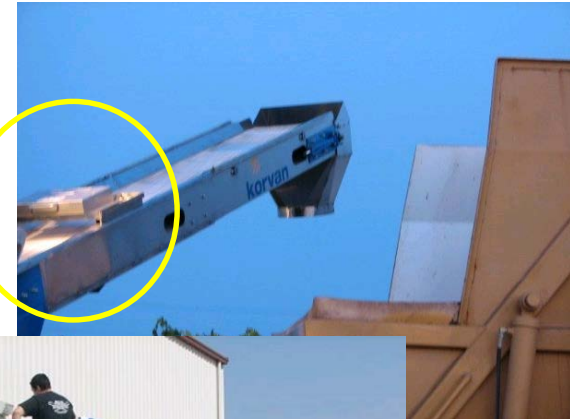


Mechanical Harvest Quality Concerns

- Machine harvested grapes will contain a higher percentage of MOG
- Reasons:
 - Poor trellising
 - Poor training
- All MOG will not be removed
- MOG will cause off-flavors in wine
- Cultivars that are more difficult to harvest will contain more MOG than others

Mechanical Harvest Quality Concerns

- Vineyards Trellised with wooden posts
 - Harvest conveyors will have to have MAGNETS to remove nails, spikes etc.
- Suction Cleaning Fans
 - Leaves are lighter than berries
 - These suck leaves into a chute
 - The fans chop up the leaves to shoot them out the back



Mechanical Harvest Quality Concerns

Temperature and Time

- Negative flavor can occur within a very short period of time
 - Less than 4 h
 - At high temps (25-35C)
 - Temperature from time of harvest to time of processing may influence
- Delay between mechanical harvesting and delivery to the winery will result in
 - Increased enzymatic activity
 - Browning
 - Oxidation
 - Off-flavors
 - Microbial growth



- Hot grapes will lead to:
 - Poor color
 - Produce high levels of alcohol
 - Acetic acid

MOG

- Material Other than Grapes
 - Canes
 - Leaves & Petioles
 - Other Debris
- Allowable Levels are quite low
 - 2-5% by weight
- How to Avoid
 - Proper Harvester Settings - Don't Pick It!
 - Remove It...

Proper Harvester Settings

Bow Rod Machine

- Rod tension
- Pinch gap / rod overlap
- # of rods
- Spacing between rods (vertically)
- Placement of rods (height)
- Head speed (RPM)
- Travel speed (MPH)

- Driver must stay centered!

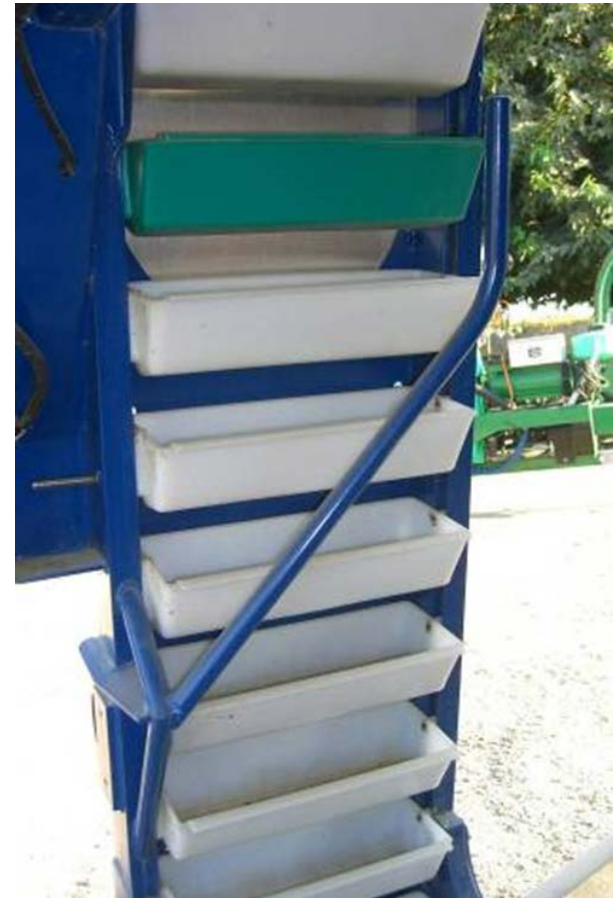
Trunk Shake Machine

- Head tuning – weights must be in time
- Pinch pressure/Pinch Spacing
- Placement of rails (height)
- Head speed (RPM)
- Travel speed (MPH)

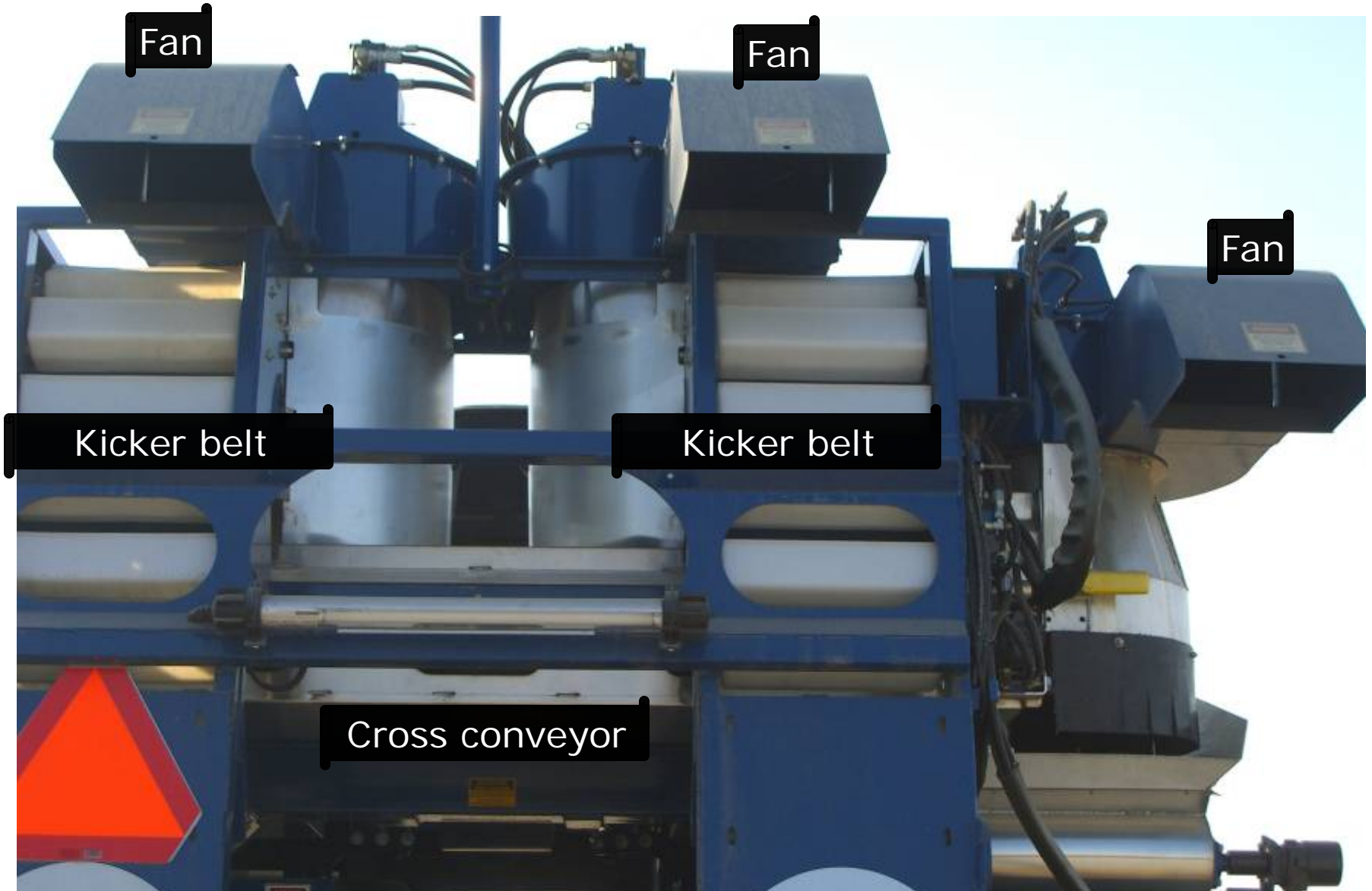
- Driver must stay centered!

MOG Pre-Cleaning Systems

- Rotary MOG Deflector
 - RPM, Direction, and Position is Adjustable
 - Removes loose debris
 - Leaves
 - Canes
 - Green shoots
 - Prevents Balling-Up in lower corner of bucket line
 - Eliminates Need for “Walkers”
- MOG slider tubes
 - More of a Passive device
 - Stationary mounted at rear of harvester
 - Guide large canes and sticks off to the side and out of the buckets



Upper Belts and Fans



Fan

Fan

Fan

Kicker belt

Kicker belt

Cross conveyor

Main Conveyor System

- Upper “kicker” belts
 - catch fruit from the bucket lines
 - Direct fruit inward and under the primary cleaning fans
- Lower “cross conveyor”
 - collects fruit from kicker belts and directs fruit toward OTR conveyor



Cleaning Fans

Three cleaning fans pull large amounts of air through the fruit at “air drops”

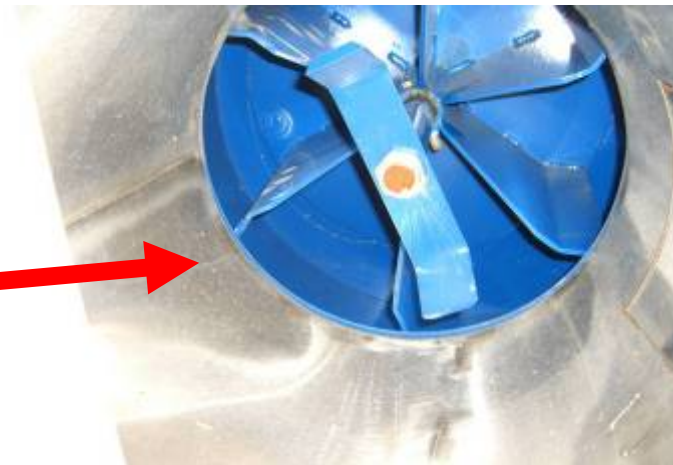
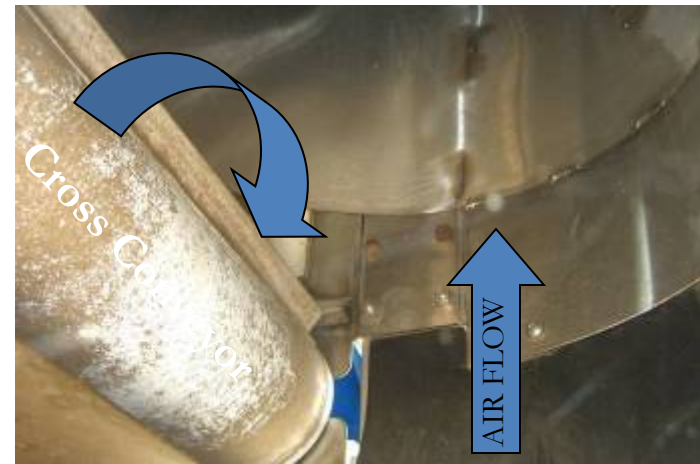
Two primary fans
One secondary fan

Leaves are the primary goal
Smaller canes and green shoots too

Secondary Final Fans

- Mounted at the outer end of the Cross Conveyor
 - Fruit falls through air drop and lands onto the OTR conveyor
 - Speed is adjustable - independent of other fans
- Stick breaker
 - Grabs canes
 - Reduces clogging

Air Chute to Fan



OTR (Over The Row) Conveyor System

Conveys fruit from final air drop area, over the adjacent row, and into a companion gondola or bin trailer

- Swing and Height are hydraulically adjustable by operator
- Optional high power magnet removes ferrous materials, like:
 - pieces of wire
 - staples
 - VSP clips
 - Wrenches
 - Screwdrivers
 - ***Things that might demolish an expensive pump at the winery!***



- Use 2 gondolas in heavy yields or long rows!

Cultivar Differences

- The same harvester settings will not work in every vineyard
- Adjustments must be made to optimize the harvest
- Certain cultivars are quite easy to harvest by machine
- Other cultivars are challenging

Mechanical harvesting difficulty of common wine grape cultivars in California based on harvester head type.

Cultivar	Pivotal striker	Bow-rod striker	Trunk shaker
Chardonnay	Easy	Easy	Medium
Riesling	Easy	Easy	Easy
Pinot gris	Medium	Easy	Medium
Sauvignon blanc	Easy	Easy	Easy
Cabernet Sauv.	Medium	Easy	Easy
Merlot	Difficult	Medium	Easy
Zinfandel	Medium	Medium	Difficult

Taken from “Wine Grape Varieties in California”. UCANR pub. 3419. Christensen et al. (2003).

Trellis and Training

- Vineyard design and maintenance plays a big role in mechanical harvesting success
 - Good stakes and cross-arms
 - Short cordons (<4 ft for trunk shake)
 - Tight cordon and foliage support wires
 - Trunks, heads, and cordons are well supported, tied and kept inline with the row
- It's all about energy transfer and rapid reversals from the harvester, through the trellis/vine combo, to the grapes.
- When things are sloppy in the vineyard, you're going to get a sloppy harvesting job.
 - *You can't push a rope!*

Quality Control Issues

- **% of Fruit Remaining**
 - 1-2%, up to 5% is OK, really!
 - Don't "over-pick"
 - Leave Rot and Raisins on the vine
- **% Leaf Area Remaining**
 - 50% is supposed to be enough for vine recovery
 - 70-80% is much better
- **Damage to trunks, cordons, arms, spurs, etc.**
- **Trellis Damage**
- **Fruit Damage / Juicing**
- **M.O.G. level**
- **Fruit Temperature**
 - During harvest primarily
 - Loads temps do not change rapidly
- **Oxidation Issues**
 - Time in Transit
 - Wait Time at Winery
 - Should you add potassium metabisulfite to prevent oxidation?



Table. Influence of harvest method and time from harvest to processing on ‘Chardonnay’ wines. Lodi, California (2005). From “The Evolution of Mechanized Vineyard Production Systems in California” N. Dokoozlian *Acta Horticulturae*; 2013. (978):265-278.

Treatment	Hours held before crushing	Fruit temperature at crushing (°C)	Hydroxycinnamates in wine (AU)	Wine fruit aroma intensity (1-5)¹	Wine bitterness intensity (1-5)
Best practice hand harvest	0	16.5 a	2.9 c	3.6 b2	2.3 a
	8	16.6 a	2.8 c	3.8 b	2.2 a
	16	16.9 a	3.8 b	2.6 c	2.7 b
Best practice machine harvest	0	12.2 b	2.0 d	4.4 a	2.1 a
	8	12.4 b	2.1 d	4.5 b	2.2 a
	16	13.0 b	4.5 a	1.3 d	3.2 bc

1 ¹ = low intensity, 5 = high intensity.

2 Numbers followed by the same letter within columns are not significantly different at the 5% level (DMRT).

Examining Different Picking Heads and Methods

Evaluation of Machine- *vs.* Hand-Harvested Chardonnay

GARTER D. CLARY^{1*}, ROBERT E. STEINHAUER²,
JAMES E. FRISINGER³, and THOMAS E. PEFFER⁴

Am. J. Enol. Vitic., Vol. 41, No. 2, 1990

- Trunk shakers
- Strikers
- Hand harvest
 - Evaluate the efficiency of fruit removal to:
 - Quantify fruit and juice losses
 - Determine juice yield
 - Determine wine quality

Results

- Stem content of Hand harvested grapes
- Second crop left on the vine on Hand Harvest grapes
- Machine picked grapes yield consideration**
- Amount of MOG delivered **

Table 1. Effect of harvest method on yield, stem content, vine and ground loss, and second crop.

Treatment	Harvested Yield	Stem Content	Vine Loss (kg/ha)	Ground Loss	Second Crop	MOG (%)
Cane shaker	12509	155 a*	77a	317	13a	1.3
Trunk shaker	12475	288 b	35a	249	1a	0.7
Hand harvest	12800	524 c	246 b	338	636 b	0.5
Significance of F:	ns	0.01	0.01	ns	0.01	—

*Means within columns separated by Duncan's new multiple range test at the 0.01 level.

Juice Loss Determination

- Assume there is no juice loss in hand harvesting for calculations
- For Chardonnay
 - 5.7% for the Striker
 - 8.0% for the Trunk Shaker

Table 2. Effect of harvest method on juice loss.

	Cane Shaker	Trunk Shaker (kg/ha)	Hand Harvest	Difference		
				Cane vs. Hand	Trunk vs. Hand (kg/ha)	Hand
Harvester Yield (t/ha)	12.59	12.54	12.88			
(kg/ha)	12509	12475	12800	292*	325*	0
Stem content (kg/ha)	155.7	288.4	523.6	+368	+235	0
Vine loss (kg/ha)	77.2	34.7	246.1	(169)	(211)	0
Ground loss (kg/ha)	317.0	249.1	337.0	(20)	(88)	0
Second crop left (kg/ha)	13.9	1.5	635.9	(623)	(636)	0
Adjusted Harvester Yield (kg/ha)				12065	11777	12800
Significance of F:				ns	ns	ns
Juice Loss (%)				5.7	8.0	0
Significance of F:				ns	ns	ns

Winery Tests

- Temperatures at delivery were acceptable
- However, machine picking regardless of method would have advantage in warmer climates

Table 3. Effect of harvest method on juice quality.

Treatment	Temp (°C)	Yield (L/t)	SS (°Brix)	TA (g/100mL)	pH	Malic acid	K+ phenols (mg/L)	
Cane Shaker	12.8	782	22.2	0.75	3.26	4552	1140	306
Trunk Shaker	16.1	765	22.2	0.76	3.28	4409	1160	312
Hand Harvest	20.6	790	22.6	0.74	3.27	4137	1200	327

Winery Tests (cont.)

- No adverse effect on phenolic content on juice
- As harvest temp increased: must phenolic concentration increased
- TSS was slightly lower for machine picked grapes
- MA was slightly higher in machine picked grapes

Table 3. Effect of harvest method on juice quality.

Treatment	Temp (°C)	Yield (L/t)	SS (°Brix)	TA (g/100mL)	pH	Malic acid	K+ phenols (mg/L)	
Cane Shaker	12.8	782	22.2	0.75	3.26	4552	1140	306
Trunk Shaker	16.1	765	22.2	0.76	3.28	4409	1160	312
Hand Harvest	20.6	790	22.6	0.74	3.27	4137	1200	327

Effect of Harvest Method on Wine Quality

- No discernible differences in wine chemistry

Table 4. Effect of harvest method on wine quality.

Treatment	VA (g per 100mL)	RS (w/v)	TA (g per 100 mL)	pH	Vol. alc. (v/v)	Malic acid ----(mg/L)----	K+phenols	
Cane shaker	.031	.06	.80	3.40	13.91	3919	630	253
Trunk shaker	.030	.06	.80	3.41	13.95	3905	590	267
Hand harvest	.035	.07	.75	3.42	14.16	3473	560	273

How about taste differences?

Able to identify hand vs. machine
But not between different picking heads
18 months post-bottling
No difference in taste panel detection

Table 5. Duo-trio difference taste test.

Treatment comparison	Correct Responses (17 Judges)
Trunk shaker vs. hand harvest	13*
Cane shaker vs. hand harvest	13*
Trunk shaker vs. cane shaker	8

*Significant at 0.05 level

Damage to the Vineyard

Table 7. Effect of harvest treatment on stake, end post, sprinkler damage, and cane selection.

Treatment	Sprinklers	Repaired		Cane selection (0-10)*
		Stakes	End posts	
	(number in 1.6-ha plot)			
Cane shaker	4	6	0	7.9a
Trunk shaker	12	5	1	8.1a
Hand harvest	4	0	1	9.3b
Significance of F	-	-	-	.01

*0 = no cane selection, 10 = no cane damage.

Thank-you!

Kaan Kurtural, UC Davis Viticulture Specialist

skkurtural@ucdavis.edu

Lynn Wunderlich, UC Cooperative Extension Farm
Advisor

lrwunderlich@ucanr.edu