Mechanical Management Tasks in the Vineyards
S. Kaan Kurtural
Driving Factors for Mechanization and Mechanical Management

Mechanization
- Timeliness of cultural practices
- Willing labor force
- Cost of labor ($15/h)
- Quality of life socioeconomic factors
- Proximity to population centers
- Land availability and cost
- Foreign competition
Evolution towards spatio-temporal management of vineyards

Present Approach
- Uniform vineyard and soil management
  - Bulk or composite vine and soil sampling

Interim Approach
- Zone vineyard and soil management
  - Stratified random sampling within zone

Future Approach
- Site-specific vineyard and soil management
  - Fine grid sampling or sensing/scanning

Increasing resolution for measurement and treatment
What can we do in vineyards mechanically?

- Dormant pruning *
- Suckering
- Shoot thinning *
- Leaf removal *
- Berry/cluster thinning *
- Harvest

### Table

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# Mechanical cultural practices and trellis type adaptability

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Trellis Systems used in California for High Efficiency Mechanical Production

Singe high wire system
- 62 to 66 inch tall
- Single canopy
- Non-shoot positioned
- ~35% exposed leaf area
- Production in 18 months
- 11 to 24 t/A in 7 ft x 10 m plant density

High Quadrilateral System
- 68 inch tall
- Divided canopy
  - 36 to 48 inch cross-arm
- Non-shoot positioned
- ~70% exposed leaf area
- Production in 18 months
- 14 to 32 t/A in 6 ft x 11 ft plant density
High production systems

Single high-wire

High quadrilateral
Desirable Aspects at harvest

Uniformly ripe fruit
Sound fruit
An abundance of flavor
  • With correct composition
Reaches peak at ideal time
  • Avoiding inclement weather
  • Winery logistics

BUT…..
YIELD IS PARAMOUNT
Grapevine fruiting characteristics

Fruiting shoots are born on one-year old dormant buds

Because of this character trait, we prune to replace the fruiting wood each year

Pruning results in removal of 80 – 90% of the dormant canes per year
Terminology

Pruning: removal of plant parts for horticultural objectives

- Controls size and form of the grapevine
- Optimizes the production potential of the grapevine
- Maintains the balance between vegetative and fruiting growth
Effects of pruning on the vine

1) A vine can only ripen a certain amount of clusters in a given season.
2) Pruning has a depressing effect on the vine.
3) Capacity of the vine directly related to number of shoots retained.
4) Production of crop depresses vine capacity.
5) Shoot vigor is indirectly related to cluster number.
6) Bud fruitfulness is indirectly related to shoot vigor.
7) Old growth (a large cane, arm) can carry more fruit vs. newly established cordon.
Types of equipment available

- **Pre-pruners**
  - Various manufacturers
  - Various materials of construction
  - May only do one plane of cut
  - Mostly adapted to VSP type canopies
  - Have to follow up with manual operations

- **Combination pruners**
  - Multiple planes of cuts
  - May be used for pre-pruning, as well as a finish and precision pruner
  - Maybe used in many types of canopies including split-canopies and California-sprawl

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**Figure 1.** Mechanical pruning can be practiced with a wide range of pruning severities, which influence the need for crop adjustment during the growing season and the potential for disease pressure.
Dormant pruning

When?
- Depends on where you are
- Dormant season
- Incidence of rain

Severity
- Defines bearing surface
- Capacity

Costs:
- Spur: $0.29/vine
- Cane w/ tying: $0.48/vine
- Mechanical w/ hand follow up: $0.36/vine
- Box-prune single-high wire: $0.07/vine
How do you set up a mechanical pruning head?

Spur height
- Sets the height of the bearing surface
  - Commonly:
    - 4 inches = Precision prune
    - 6 inches = Pruning + follow up
    - 8 inches = Pre-pruning

Bearing surface girth
- Set the width and depth of bearing surface
  - Commonly
    - Sprawl: Completely removed
    - Width: 4 to 6 inches

Ground speed
- T-top or VSP canopy
  - 1.0 to 1.5 miles/h
- Single high-wire
  - 2.0 miles/h

Measure, and measure often!
Parts of a mechanical pruner
Shoot thinning

When?
During dormant pruning*
Trunk suckering
  • 1” – 3” shoot length
Cordon
  • 8” – 12” shoot length

In FROST PRONE AREAS WAIT TILL ALL DANGER OF FROST HAS PASSED!

Reduces shoot density, but impact on canopy density is often temporary if irrigation is unchecked

Efficient method of crop thinning
Assists in the establishment of spur positions
Reduces pruning costs next season

Cost per acre - $80 – $300/acre
How do you set up a mechanical shoot thinner?

Consider:

• Target shoot density:
  • Count shoots
  • Non-count shoots
• Cordon brush
• Rotary paddles
  • 2 to 12 paddles
• Tractor ground speed
  • 1 to 1.2 miles/h
## Yield averages 2009-2011 (Syrah/1103 P)

<table>
<thead>
<tr>
<th>Canopy Management</th>
<th>Berry wt (g)</th>
<th>Cluster wt (g)</th>
<th>Yield (T/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>1.33 a</td>
<td>189 a</td>
<td>7.0 b</td>
</tr>
<tr>
<td>5 shoots/ft</td>
<td>1.30 ab</td>
<td>151ab</td>
<td>8.3 c</td>
</tr>
<tr>
<td>7 shoots/ft</td>
<td>1.26 b</td>
<td>148 c</td>
<td>12.1 ab</td>
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<tr>
<td>15 shoots/ft</td>
<td>1.20 c</td>
<td>137 d</td>
<td>15.0 a</td>
</tr>
<tr>
<td>( p )</td>
<td>0.0191</td>
<td>0.0008</td>
<td>0.0006</td>
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</table>

### RDI

| SDI               | 1.35 a       | 172 a         | 14.0 a      |
| RDIE              | 1.13 b       | 126 b         | 12.1 b      |
| RDIL              | 1.33 b       | 172 a         | 13.9 a      |
| \( p \)           | 0.0001       | 0.0001        | 0.0001      |

### CM x RDI

| CM x RDI | 0.0802 | 0.0499 | 0.6897 |
Pruning weights

Terry and Kurtural 2011
Effects of shoot density on berry chemistry of Syrah/1103P

Table 6 Effects of mechanical canopy management and timing and severity of regulated deficit irrigation (RDI) on average berry skin phenolics, anthocyanins, and tannins of Syrah/1103P grapevines during harvest at 23 Brix in 2009 and 2010 (n = 48).

<table>
<thead>
<tr>
<th>Canopy</th>
<th>Total phenolics (µg·g⁻¹)</th>
<th>Anthocyanins (µg·g⁻¹)</th>
<th>Tannins (µg·g⁻¹)</th>
<th>Total phenolics (µg·g⁻¹)</th>
<th>Anthocyanins (µg·g⁻¹)</th>
<th>Tannins (µg·g⁻¹)</th>
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<tbody>
<tr>
<td>Hand pruned (HP)</td>
<td>875.9 b&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>496.2 c</td>
<td>417.3 b</td>
<td>685.9 c</td>
<td>527.9</td>
<td>355.3</td>
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<tr>
<td>Crop load low CLL</td>
<td>973.1 a</td>
<td>560.4 b</td>
<td>463.5 a</td>
<td>795.7 a</td>
<td>552.4</td>
<td>351.9</td>
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<tr>
<td>Crop load mid (CLM)</td>
<td>980.2 a</td>
<td>607.2 a</td>
<td>468.3 a</td>
<td>832.1 a</td>
<td>545.5</td>
<td>400.1</td>
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<tr>
<td>Crop load high (CLH)</td>
<td>954.2 ab</td>
<td>604.2 ab</td>
<td>462.5 a</td>
<td>724.9 b</td>
<td>542.2</td>
<td>363.9</td>
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<tr>
<td>Pr &gt; F</td>
<td>0.0289</td>
<td>0.0471</td>
<td>0.0426</td>
<td>0.0421</td>
<td>0.0501</td>
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<td>Control (RDIC)</td>
<td>909.3 b</td>
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<td>398.1</td>
<td>699.7 c</td>
<td>525.1 b</td>
<td>295.3 c</td>
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<tr>
<td>Early (RDIE)</td>
<td>1092.9 a</td>
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<td>542.0</td>
<td>826.5 a</td>
<td>570.9 a</td>
<td>408.9 a</td>
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<td>Late (RDIL)</td>
<td>864.7 b</td>
<td>268.8 c</td>
<td>449.2</td>
<td>750.9 b</td>
<td>530.8 b</td>
<td>398.4 b</td>
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<td>Pr &gt; F</td>
<td>0.0353</td>
<td>0.0356</td>
<td>0.1096</td>
<td>0.0324</td>
<td>0.0120</td>
<td>0.0024</td>
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<tr>
<td>Interaction&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.9921</td>
<td>0.8825</td>
<td>0.8710</td>
<td>0.9096</td>
<td>0.5849</td>
<td>0.9837</td>
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<sup>a</sup>Significance for main and subplot and interaction according to type III tests of fixed effects.

<sup>b</sup>Means separated by a letter are significantly different according to Tukey’s HSD test at Pr > F 0.05.

<sup>c</sup>Interaction of canopy management x RDI.

Terry and Kurtural 2011
Red Wine Flavor Indicators

**IBMP (green flavor)**

- Brillante et al. 2018

**B-damascenone (jammy, fruity flavor)**

- Brillante et al. 2018
Berry/Cluster thinning

Pre-bloom thinning

Post fruit set-thinning
  • Rule of thumb for post fruit-set cluster thinning
  • If shoot is < 12” long remove all clusters
  • If shoot 12” – 24 “ long retain one cluster
  • If shoot > 24” long retain 2 clusters

We are seeing most beneficial responses if applied
  • Berries b-b size
  • Post veraison applications – self gratifying
Manual cluster thinning
Mechanical fruit thinning
# Effect of cluster numbers on canopy variables and fruit composition

<table>
<thead>
<tr>
<th>Clusters</th>
<th>$\gamma$ (cm²/cm)</th>
<th>LLN (cm)</th>
<th>$\Delta$ shoots (cm)</th>
<th>TSS(%)</th>
<th>pH</th>
<th>TA(g/L)</th>
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<tr>
<td>1 per</td>
<td>32.1</td>
<td>3.7</td>
<td>8.1</td>
<td>23.2 a</td>
<td>3.43 a</td>
<td>8.0</td>
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<tr>
<td>2 per</td>
<td>23.8</td>
<td>2.7</td>
<td>7.8</td>
<td>21.9 b</td>
<td>3.34 b</td>
<td>7.7</td>
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<td>&gt; 2 per</td>
<td>27.0</td>
<td>3.0</td>
<td>8.3</td>
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<td>7.6</td>
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P

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Kurtural et al. 2006
Leaf Removal

Severity

- Both sides of the canopy
- Shade side of the canopy
  - East side if rows N-S *
  - North side if rows E-W
- Cost
  - $80 to $250/acre depending on
  - Trellis type
  - Hand vs. Machine
  - Timing
  - Canopy density
Types of equipment available

Suck and cut type leaf removal implements
- Mostly adapted to VSP trellis
- Damage to flower cluster and clusters
- Did not work well in sprawling canopies

Air-blast type leaf removal implements
- Mostly adapted to VSP trellis
- Did not work as well in sprawling canopies
- Little to no damage to flower cluster and clusters

Roll-over type leaf removal implements
- Adapted to VSP, sprawling and split canopy systems
- Selective
- Little to no damage to flower cluster and clusters
Leaf removal
Leaf removal

Pre-bloom
- Catechin/epicatechin monomer
- Total skin flavonols
- Total skin anthocyanidins

Post-fruit set
- Berry Skin Mass
- Total skin flavonols
- EGC (Extension subunits)
- Mean Degree of polymerization
- Total Skin PAs (by ploroglucinolysis)
- Conversion yield (skin)

Water deficits

Sustained Deficit Irrigation
- Berry mass

Regulated Deficit Irrigation
- Berry mass
- Yield (2014)
- Leaf area:fruit ratio (2014)

Yu et al. 2016
Table 6: Effects of mechanical leaf removal and fractions of crop evapotranspiration application on labor operations cost of canopy management and cost of producing total skin anthocyanins per hectare in northern San Joaquin Valley of California (n = 4).

<table>
<thead>
<tr>
<th>Year</th>
<th>Treatment</th>
<th>Pruning cost ($/ha)</th>
<th>Leaf removal cost ($/ha)</th>
<th>Irrigation applied (ML/ha)</th>
<th>Irrigation water cost ($/ha)</th>
<th>TSA production (g/ha)</th>
<th>TSA unit cost ($/g)</th>
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<td>2013</td>
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<td>748</td>
<td>0</td>
<td>2.37</td>
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<td>0</td>
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<td>1,718 b</td>
<td>0.92 bc</td>
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<td>0.0001</td>
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<tr>
<td>2014</td>
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<td>1,657 a</td>
<td>1.21 c</td>
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<td>2.60</td>
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<td></td>
<td></td>
<td>0.0001</td>
<td>0.0001</td>
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</tbody>
</table>

\*TSA: total skin anthocyanin (g) produced per hectare.
\*Columns followed by a different letter are significantly different according to Tukey’s HSD test at Pr > F 0.05.
That’s Great, so what?

You have to relate this to

- Production Efficiency

How do you measure efficiency?

Production Efficiency

Leaf area or vegetative growth

Fruit yield or reproductive growth
Production Efficiency

<table>
<thead>
<tr>
<th>Vine yield</th>
<th>Situation</th>
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<tr>
<td>Pruning weight</td>
<td></td>
</tr>
<tr>
<td>&lt; 5</td>
<td>Undercropped</td>
</tr>
<tr>
<td>5 – 10</td>
<td>Optimum</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>Overcropped</td>
</tr>
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</table>
Grapevine Balance through Canopy/Crop load Management

Balancing vegetative growth with reproductive growth
Single most important practice

Vine balance thresholds
Crop load : 5 to 10 lbs/lbs
Pruning weight/ ft of row:
• Up to 0.7 lbs/ft

• Unbalanced vines
  • Large canopies
  • High water demand
  • Fruit of inferior quality
  • High green flavors
  • Low fruit flavors
  • High priority for industry
Putting Management to Practice

White wine grape production for cool and warm climate regions
Constraints to consistent production

Profit margins are low
  • Yield is paramount in the warm climate
  • 12 tons/A
    • (based on 7’ x 11’ spacing)
Growers can only afford to prune
  • Mechanical hedging:
    • Retains too many nodes
    • **Out of balance vines**
    • Too much fruit for the amount of leaf area
    • Too much leaf area for the amount of fruit

CROP LOAD MANAGEMENT instead of Canopy Management
White Wine Grape/White Zinfandel Irrigation Strategy

Warm climate
Bud break to bloom
  • Irrigation trigger $\Psi_l = -8$ bars
Bloom to set
  • Replace 80% of ETc, $\Psi_l = -10$ bars
Fruit set to veraison
  • Replace 80% of ETc, $\Psi_l = -10$ bars
Veraison to harvest
  • Replace 80% of ETc, $\Psi_l = -10$ bars

Martinez-Luscher et al. 2017
Canopy Architecture

Warm climate

Pruning method:
- Mechanical (4” hedge)

For upright variety
- Shoot density: 11 count shoots/ft
- 4- 4.5 leaf layers

Leaf removal: None
Crop Load Management (Pinot gris/1103P)

Geller and Kurtural et al. 2013
Crop load management (Pinot gris/1103P)

Geller and Kurtural et al. 2013
Table 6  Average labor operation cost for canopy management treatments and net benefit for canopy management of Pinot gris grapevines in 2010 and 2011.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Canopy management cost/ha ($)^b</th>
<th>Gross income/ha ($)^c</th>
<th>Net income/ha ($)^d</th>
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<tbody>
<tr>
<td>HP + low ST</td>
<td>1,058.60</td>
<td>8,253.00</td>
<td>(-4,384.00)</td>
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<tr>
<td>HP + medium ST</td>
<td>1,058.60</td>
<td>9,361.26</td>
<td>(-3,275.74)</td>
</tr>
<tr>
<td>HP + high ST (control)</td>
<td>997.10</td>
<td>10,870.38</td>
<td>(-1,766.62)</td>
</tr>
<tr>
<td>MH + low ST</td>
<td>217.10</td>
<td>11,389.14</td>
<td>(-1,247.86)</td>
</tr>
<tr>
<td>MH + medium ST</td>
<td>217.10</td>
<td>12,733.20</td>
<td>96.20</td>
</tr>
<tr>
<td>MH + high ST</td>
<td>155.60</td>
<td>13,652.82</td>
<td>1,015.82</td>
</tr>
<tr>
<td>HP + low ST + LR</td>
<td>1,120.10</td>
<td>8,350.60</td>
<td>(-4,286.40)</td>
</tr>
<tr>
<td>HP + medium ST + LR</td>
<td>1,120.10</td>
<td>9,739.24</td>
<td>(-2,897.76)</td>
</tr>
<tr>
<td>HP + high ST + LR</td>
<td>1,058.60</td>
<td>10,338.07</td>
<td>(-2,298.93)</td>
</tr>
<tr>
<td>MH + low ST + LR</td>
<td>278.60</td>
<td>10,422.95</td>
<td>(-2,214.05)</td>
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<tr>
<td>MH + medium ST + LR</td>
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<td>12,143.99</td>
<td>(-4,93.01)</td>
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<tr>
<td>MH + high ST + LR</td>
<td>217.10</td>
<td>13,450.11</td>
<td>813.11</td>
</tr>
</tbody>
</table>

^aHP: hand pruning; MH: mechanical hedging; ST: shoot thinning; and LR: and leaf removal.


^cGross income/ha: mean yield per ha x average price per ton.

^dNet income/ha: gross income per ha – canopy management cost per ha.
Crop load management (Pinot gris/1103P)

Geller and Kurtural et al. 2013
What happened to the wine/with the wine?

No leaf removal

Leaf removal
Take home messages

No silver bullet
Each vineyard is unique
Not all treatments will work at every vineyard
For Red wine grapes: Incorporation of early canopy growth control is **Key** to **build** flavonoid composition, and **retain** it later in hot season
To **burn up** green flavors: Early season exposure is the only thing that works.
To **increase** fruity, jammy flavors: Late season exposure will enhance them, but might decrease yield due to shrivel, raisining.
For White wine grapes: Crop load management, rather than canopy management.
Acknowledgements

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