Mechanical Management Tasks in the Vineyards

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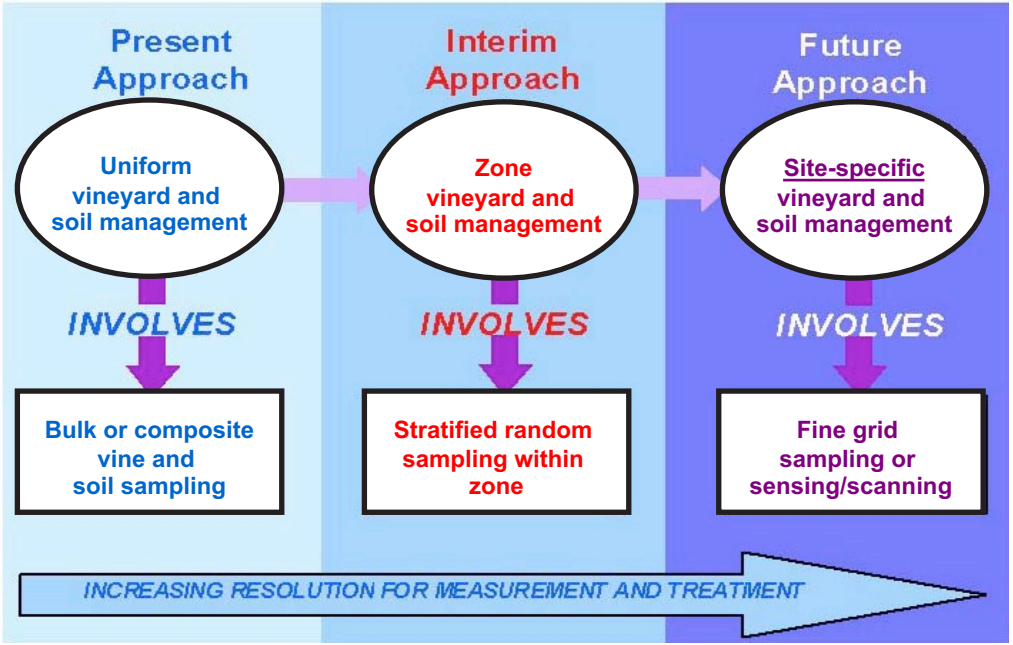
Driving Factors for Mechanization and Mechanical Management

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



What can we do in vineyards mechanically?

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

	Wine	Raisin	Table
Harvesting	90	35	-
Pruning			
Pre-prune	65	5	30
Box-hedge	12	-	-
Canopy Mgt			
Leaf removal	45	-	10
Shoot thinning	7	-	-
Hedging	100	100	100
Shoot positioning	2	-	-
Crop load Mgt			
Fruit removal	7	-	-

Mechanical cultural practices and trellis type adaptability

	California sprawl	VSP	Quadrilateral	Single high wire	Head-trained
Pre-pruning	+++	++++	+++	++++	-
Final pruning	++	++	+++	++++	-
Shoot thinning	++	++	++	++++	-
Leaf removal	++	++++	++	++++	++
Berry/cluster thinning	++	++	+	++++	+
Trunk suckering	+++	+++	++	++++	+
Harvest	+++	++++	+++	++++	-

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…..

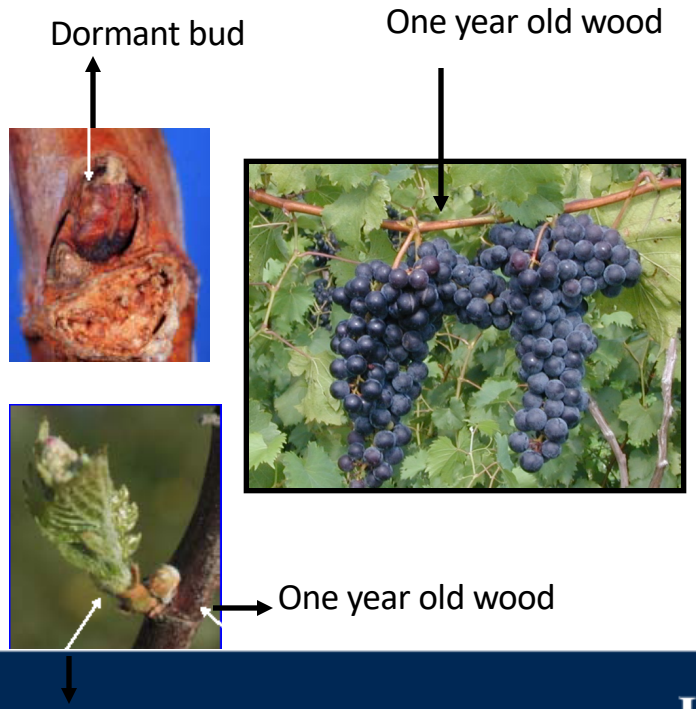
YIELD IS PARAMOUNT

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

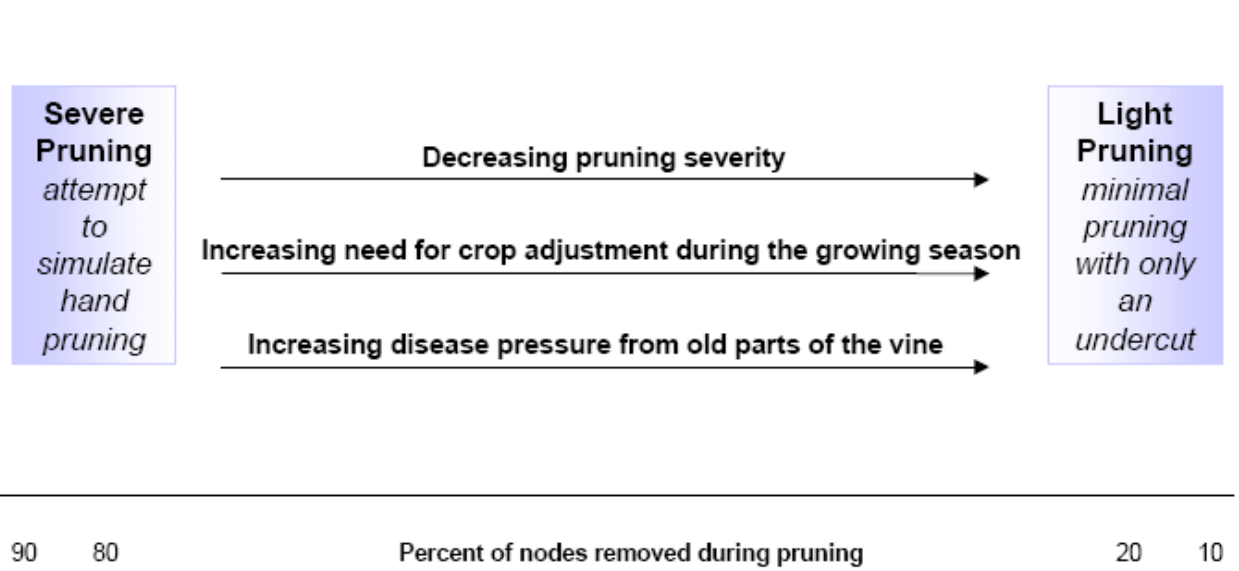
Pruning: removal of plant parts for horticultural objectives

- 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



Morris et a. 2007

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

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?

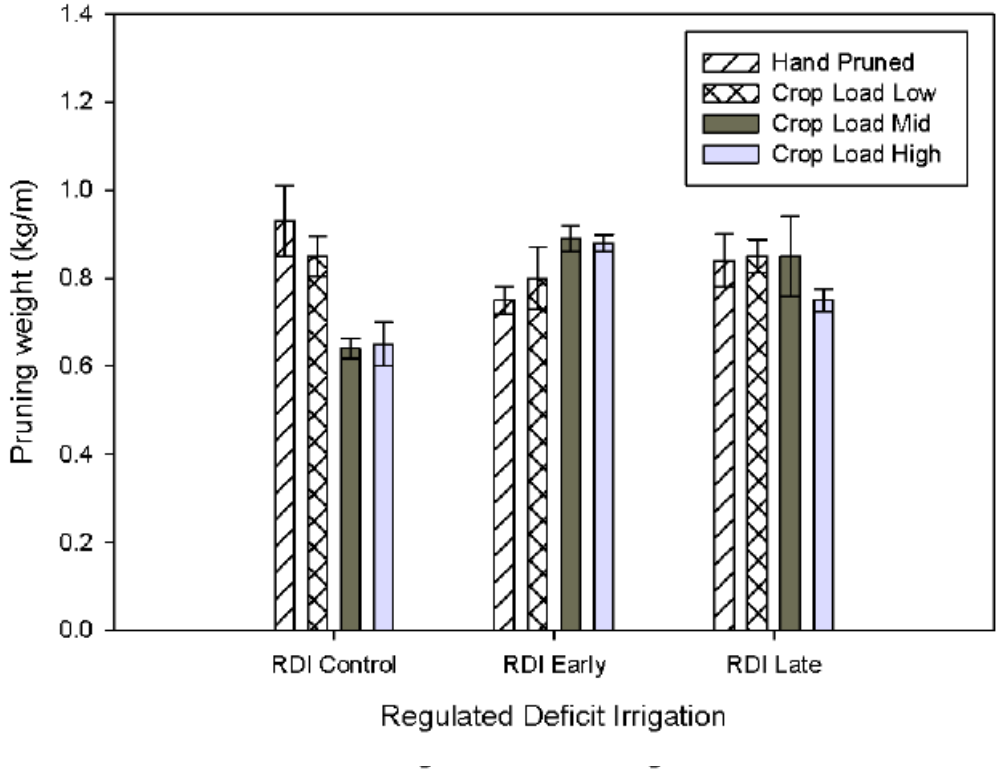
Consider:

- 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)

Canopy Management	Berry wt(g)	Cluster wt (g)	Yield (T/A)
HP	1.33 a	189 a	7.0 b
5 shoots/ft	1.30 ab	151ab	8.3 c
7 shoots/ft	1.26 b	148 c	12.1 ab
15 shoots/ft	1.20 c	137 d	15.0 a
P	0.0191	0.0008	0.0006
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	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).

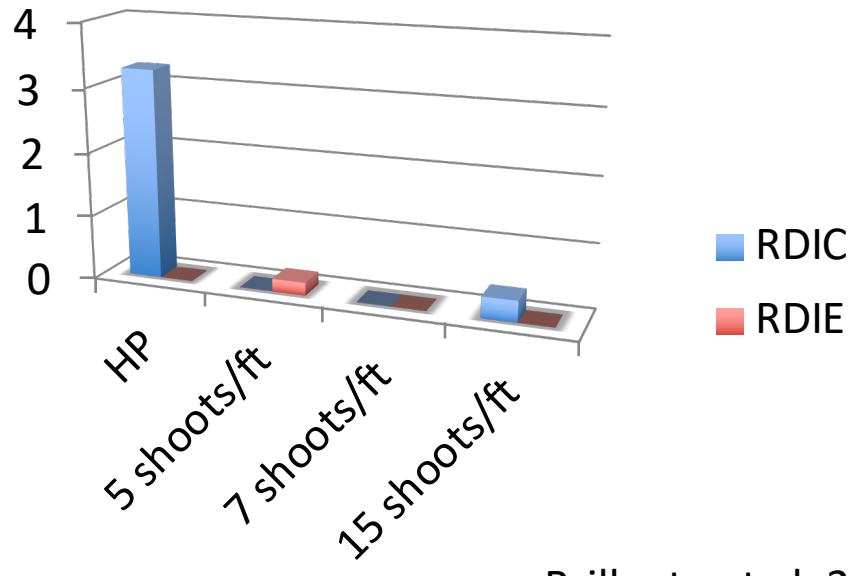
	2009			2010		
	Total phenolics ($\mu g \cdot g^{-1}$)	Anthocyanins ($\mu g \cdot g^{-1}$)	Tannins ($\mu g \cdot g^{-1}$)	Total phenolics ($\mu g \cdot g^{-1}$)	Anthocyanins ($\mu g \cdot g^{-1}$)	Tannins ($\mu g \cdot g^{-1}$)
Canopy						
Hand pruned (HP)	875.9 b[a,b]	496.2 c	417.3 b	685.9 c	527.9	355.3
Crop load low CLL)	973.1 a	560.4 b	463.5 a	795.7 a	552.4	351.9
Crop load mid (CLM)	980.2 a	607.2 a	468.3 a	832.1 a	545.5	400.1
Crop load high (CLH)	954.2 ab	604.2 ab	462.5 a	724.9 b	542.2	363.9
Pr > *F*	0.0289	0.0471	0.0426	0.0421	0.0501	0.2081
RDI						
Control (RDIC)	909.3 b	365.0 b	398.1	699.7 c	525.1 b	295.3 c
Early (RDIE)	1092.9 a	466.4 a	542.0	826.5 a	570.9 a	408.9 a
Late (RDIL)	864.7 b	268.8 c	449.2	750.9 b	530.8 b	398.4 b
Pr > *F*	0.0353	0.0356	0.1096	0.0324	0.0120	0.0024
Interaction[c]	0.9921	0.8825	0.8710	0.9096	0.5849	0.9837

[a]Significance for main and subplot and interaction according to type III tests of fixed effects.
[b]Means separated by a letter are significantly different according to Tukey's HSD test at *Pr* > *F* 0.05.
[c]Interaction of canopy management x RDI.

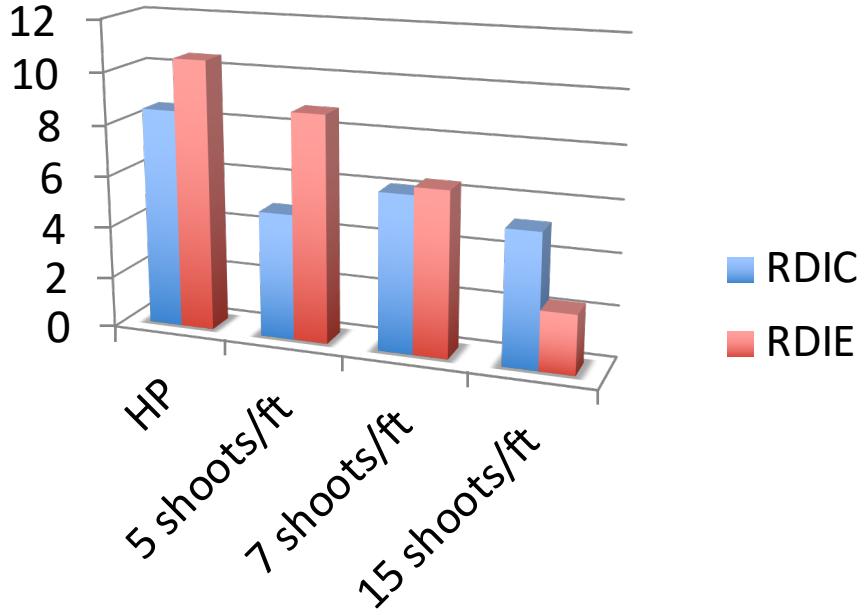
Terry and Kurtural 2011

Red Wine Flavor Indicators

IBMP (green flavor)



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

Clusters	γ (cm²/cm)	LLN	Δ shoots (cm)	TSS(%)	pH	TA(g/L)
1 per	32.1	3.7	8.1	23.2 a	3.43 a	8.0
2 per	23.8	2.7	7.8	21.9 b	3.34 b	7.7
> 2 per	27.0	3.0	8.3	21.2 a	3.29 b	7.6
P	*0.1601*	*0.2691*	*0.7721*	*0.0001*	*0.0014*	*0.1332*
Trend	NS	*NS*	*NS*	*Linear* ***	*Linear* **	*NS*

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

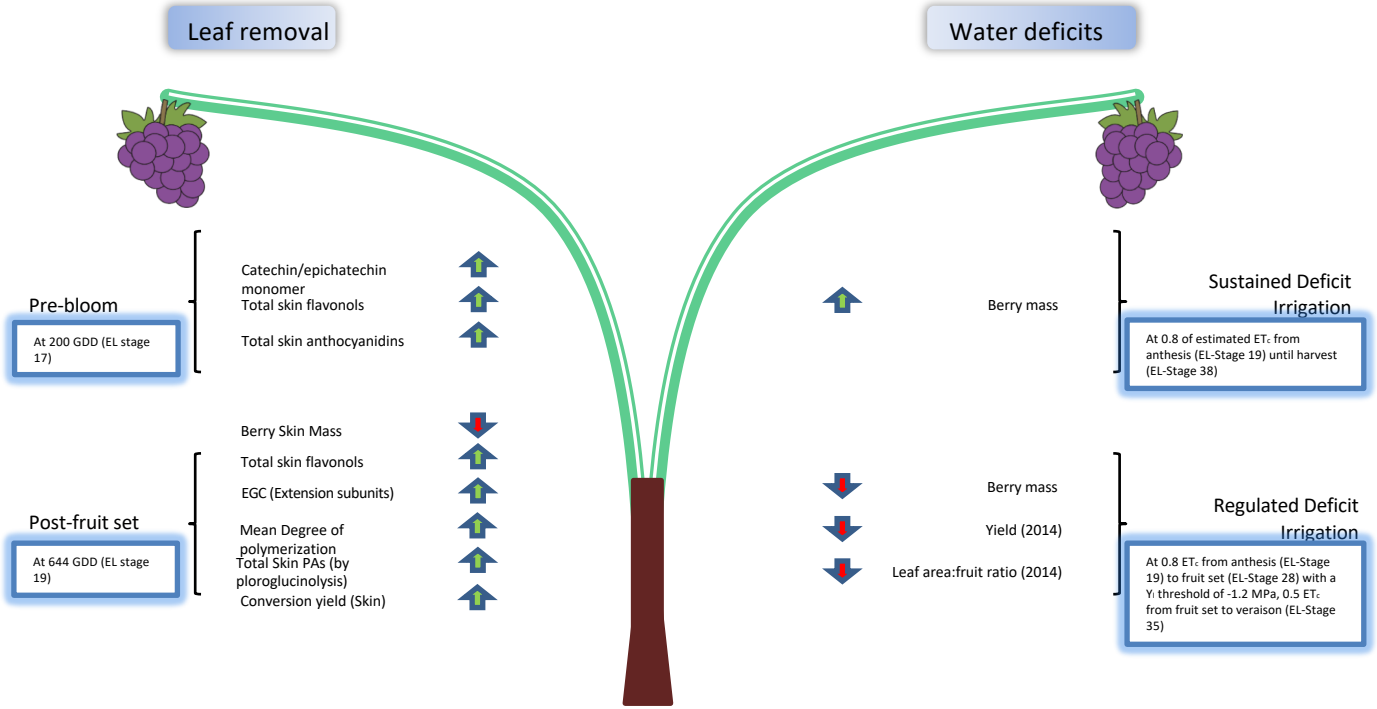
Air-blast type leaf removal implements

- 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
Water deficits
Pre-bloom
At 200 GDD (EL stage 17)
Catechin/epichatechin monomer
Total skin flavonols
Total skin anthocyanidins
Post-fruit set
At 644 GDD (EL stage 19)
Berry Skin Mass
Total skin flavonols
EGC (Extension subunits)
Mean Degree of polymerization
Total Skin PAs (by ploroglucinolysis)
Conversion yield (Skin)
Berry mass
Sustained Deficit Irrigation
At 0.8 of estimated ETc from anthesis (EL-Stage 19) until harvest (EL-Stage 38)
Berry mass
Yield (2014)
Leaf area:fruit ratio (2014)
Regulated Deficit Irrigation
At 0.8 ETc from anthesis (EL-Stage 19) to fruit set (EL-Stage 28) with a Yi threshold of -1.2 MPa, 0.5 ETc from fruit set to veraison (EL-Stage 35)

Yu et al. 2016

Some economic data on mechanical leaf removal

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).

	Pruning cost ($/ha)	Leaf removal cost ($/ha)	Irrigation applied (ML/ha)	Irrigation water cost ($/ha)	TSA production[a] (g/ha)	TSA unit cost ($/g)
2013						
Control + SDI	748	0	2.37	950	1,086 c[b]	1.56 a
Control + RDI	748	0	2.03	827	1,718 b	0.92 bc
Prebloom + SDI	748	30	2.37	950	1,976 a	0.87 c
Prebloom + RDI	748	30	2.03	827	1,958 a	0.82 c
Post fruit-set + SDI	748	30	2.37	950	1,589 b	1.09 b
Post fruit-set + RDI	748	30	2.03	827	1,799 ab	0.89 c
Pr > F	–	–	–	–	0.0001	0.0001
2014						
Control + SDI	748	0	3.08	1,235	1,079 c	1.84 a
Control + RDI	748	0	2.60	1,029	1,261 b	1.41 b
Prebloom + SDI	748	30	3.08	1,235	1,657 a	1.21 c
Prebloom + RDI	748	30	2.60	1,029	1,552 a	1.16 c
Post fruit-set + SDI	748	30	3.08	1,235	1,062 c	1.90 a
Post fruit-set + RDI	748	30	2.60	1,029	1,181 b	1.53 b
Pr > F	–	–	–	–	0.0001	0.0001

[a]TSA: total skin anthocyanin (g) produced per hectare.
[b]Columns followed by a different letter are significantly different according to Tukey's HSD test at *Pr > F* 0.05.

Cook et al. 2015

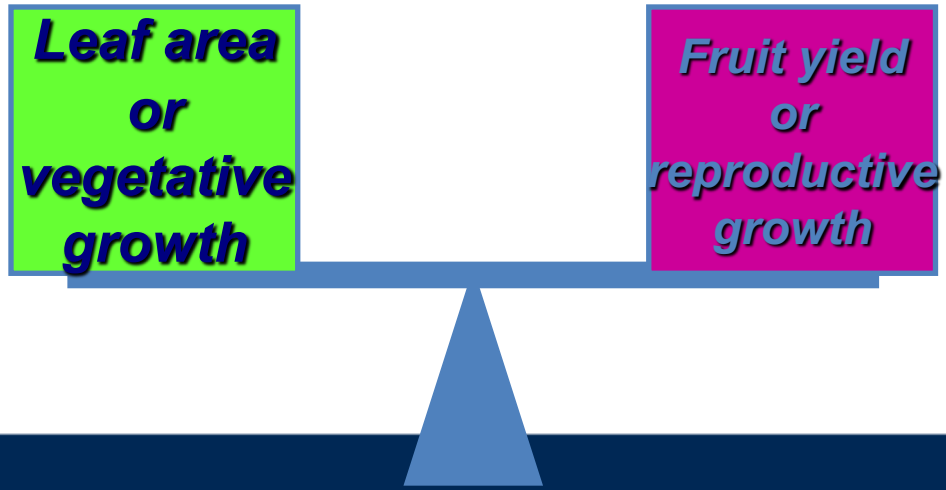
That's Great, so what?

You have to relate this to

- Production Efficiency

How do you measure efficiency?

Production Efficiency



Production Efficiency

$\frac{\text{Vine yield}}{\text{Pruning weight}}$	Situation
< 5	Undercropped
5 – 10	Optimum
> 10	Overcropped

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 Ψl = -8 bars

Bloom to set

- Replace 80% of ETc, Ψl = -10 bars

Fruit set to veraison

- Replace 80% of ETc, Ψl = -10 bars

Veraison to harvest

- Replace 80% of ETc, Ψl = -10 bars

Martinez-Luscher et al. 2017

Canopy Architecture

Warm climate

Pruning method:

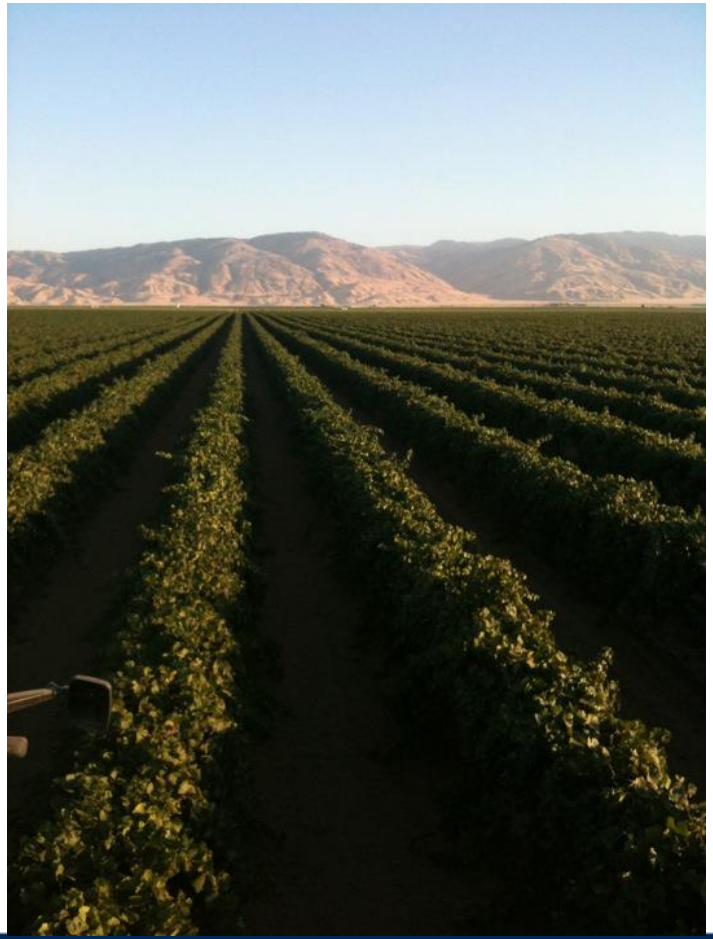
- Mechanical (4” hedge)

For upright variety

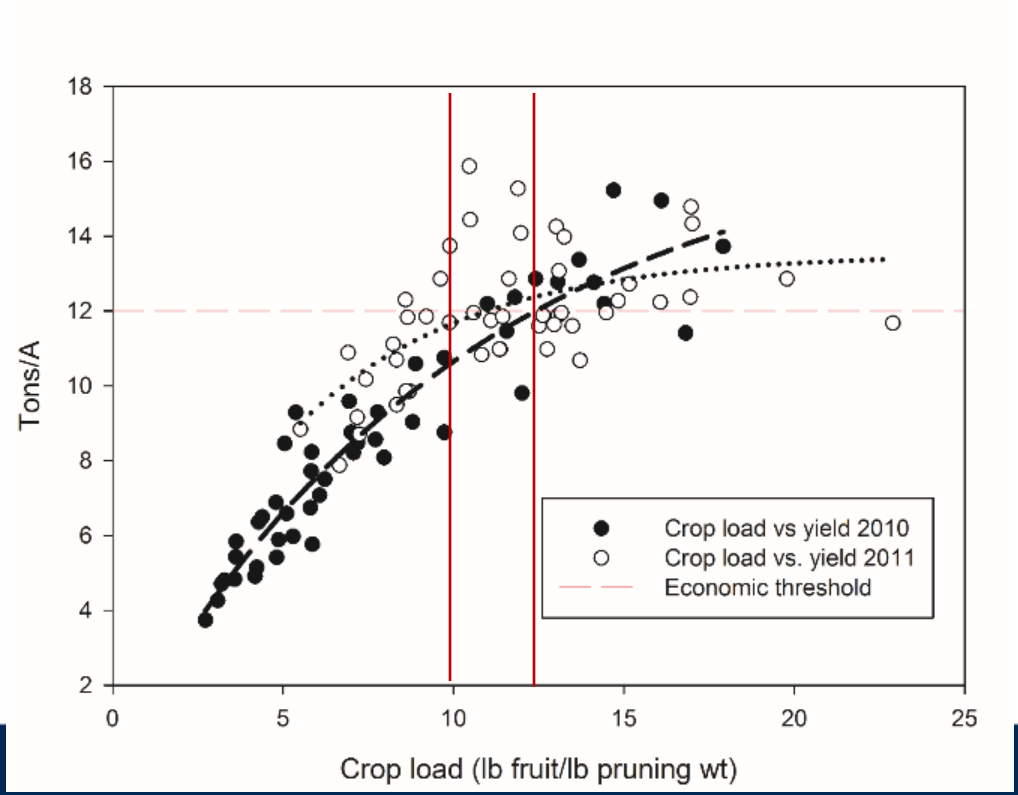
- Shoot density: 11 count shoots/ft

4- 4.5 leaf layers

Leaf removal: None

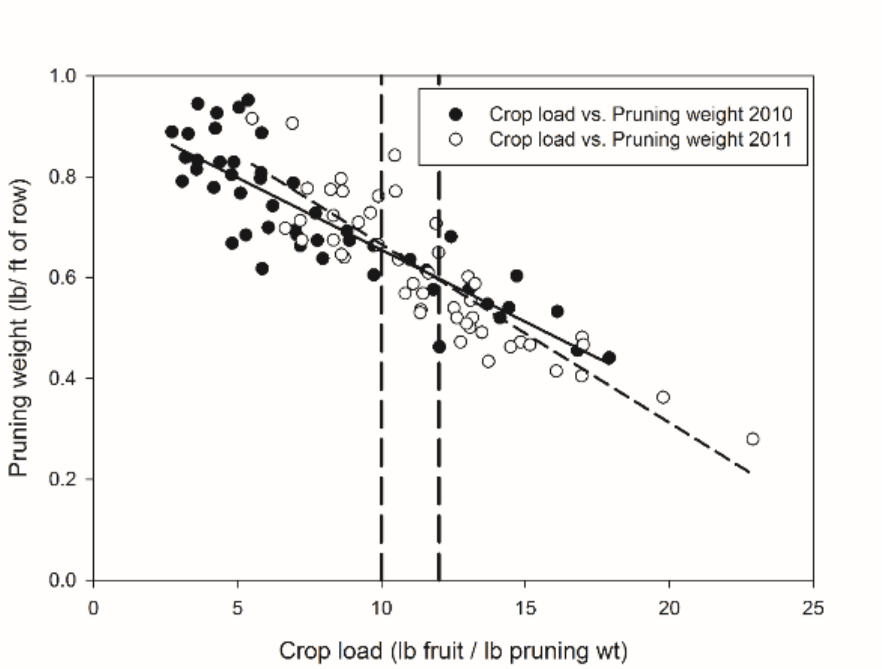


Crop Load Management (Pinot gris/1103P)



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.

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

[a]HP: hand pruning; MH: mechanical hedging; ST: shoot thinning; and LR: and leaf removal.

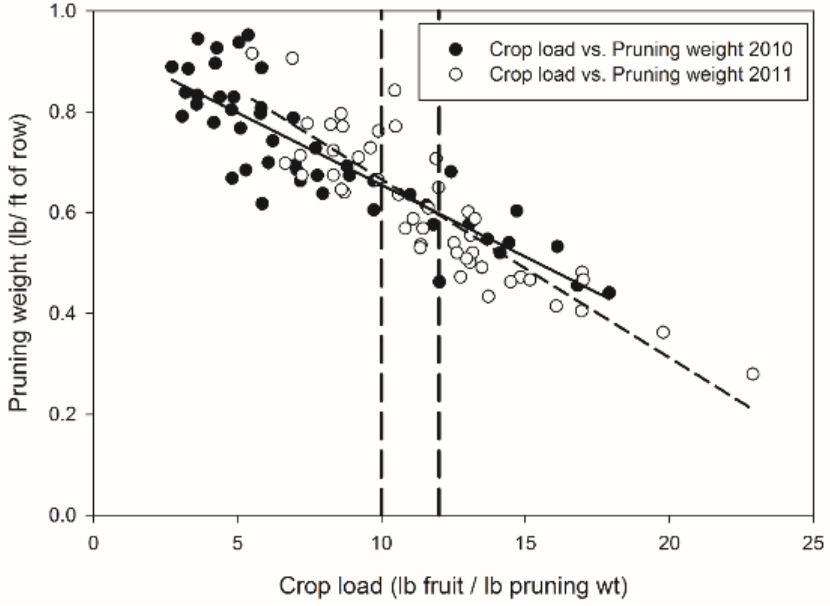
[b]Labor cost calculations per ha for canopy management (Kurtural et al. 2012, Peacock et al. 2005), based on average labor prices 2011–2012.

[c]Gross income/ha: mean yield per ha x average price per ton.

[d]Net income/ha: gross income per ha – canopy management cost per ha.

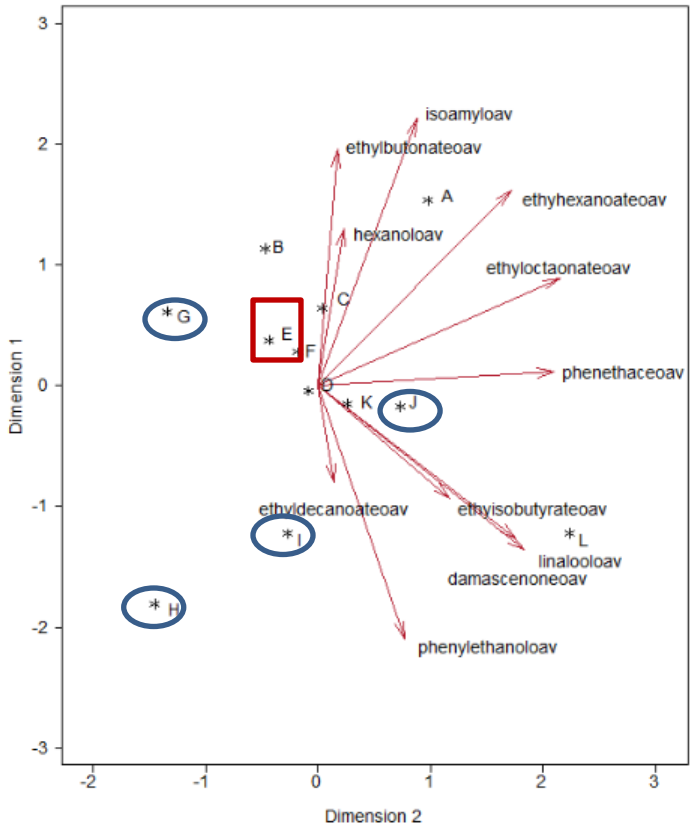
Geller and Kurtural et al. 2013

Crop load management (Pinot gris/1103P)



Geller and Kurtural et al. 2013

Wha



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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