Literature Review of Canopy Management in oil olive orchards in high density and super-high intensive olive orchards

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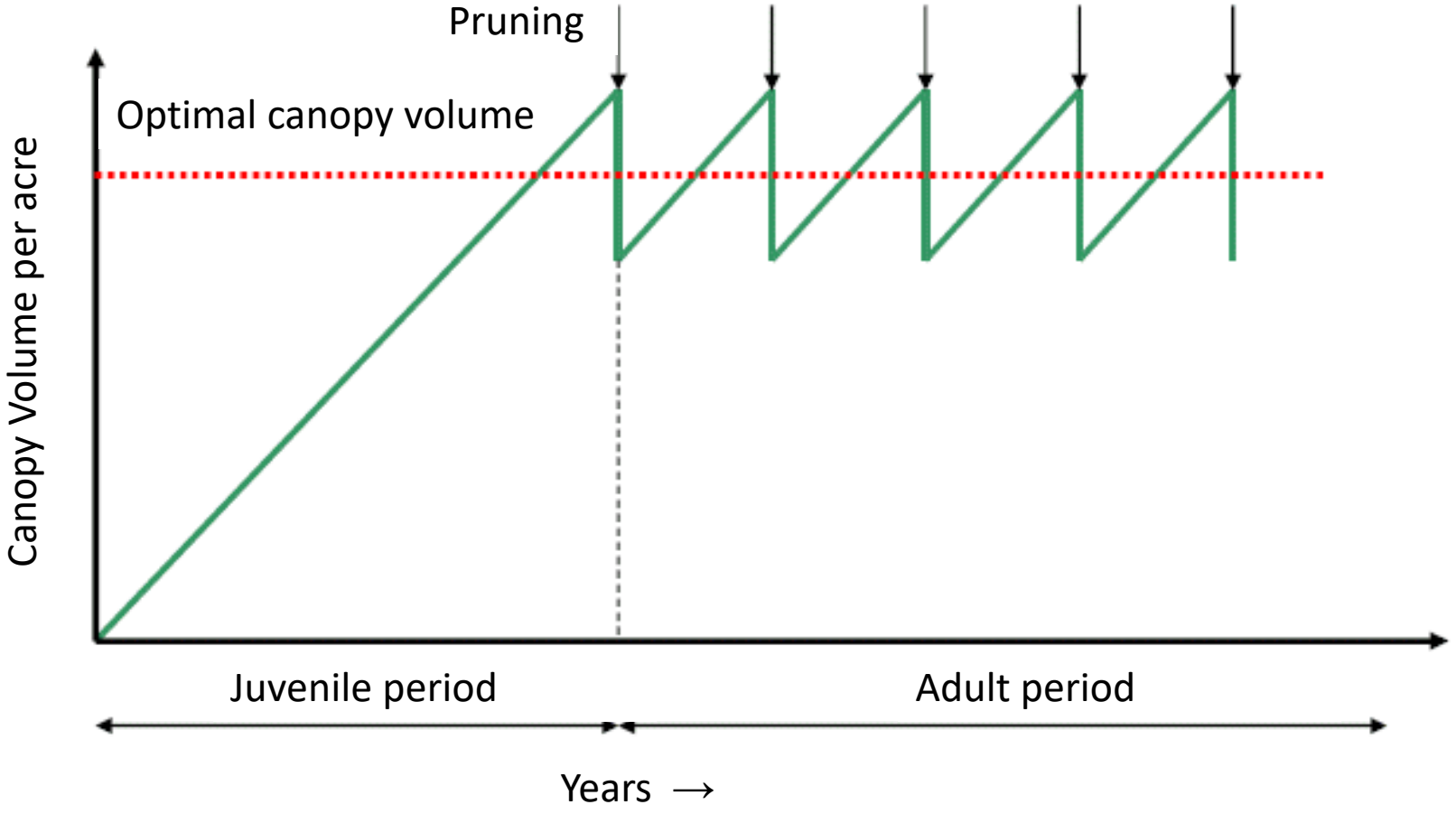
Goal: Maintain optimal canopy volume to maximize yield while maintaining mechanical access



Adopted from Ravetti, 2011

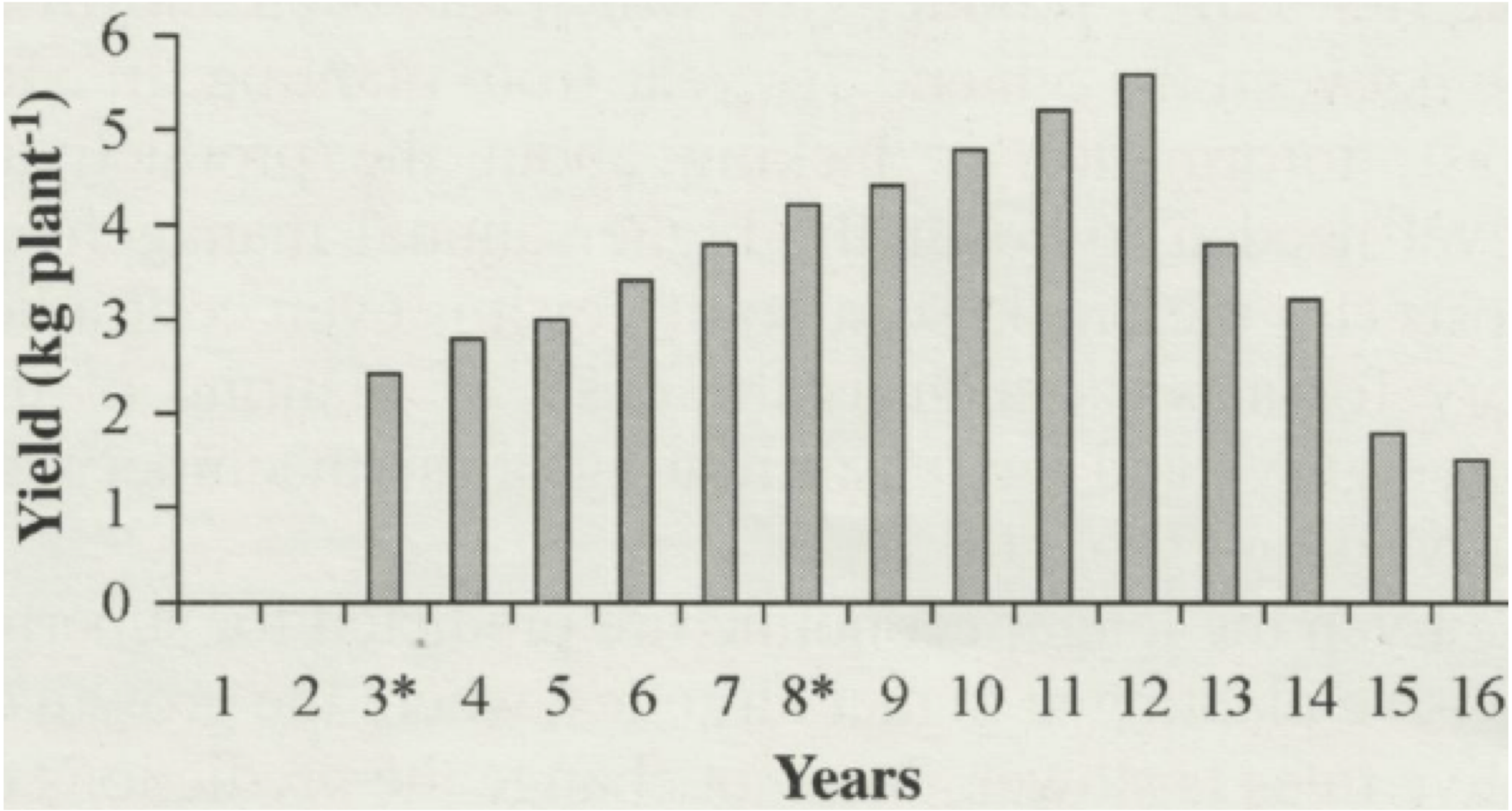
Canopy Management for Mechanical Harvest

- Harvesting is the key issue in olive production
- Primary requirement of hedgerow design is that the distance between adjacent hedgerows (i.e. alley width) is wide enough for entry of all equipment, (hedgerow dimensions should match harvesting machinery)

photo: Boundary Bend

Canopy Management Overview

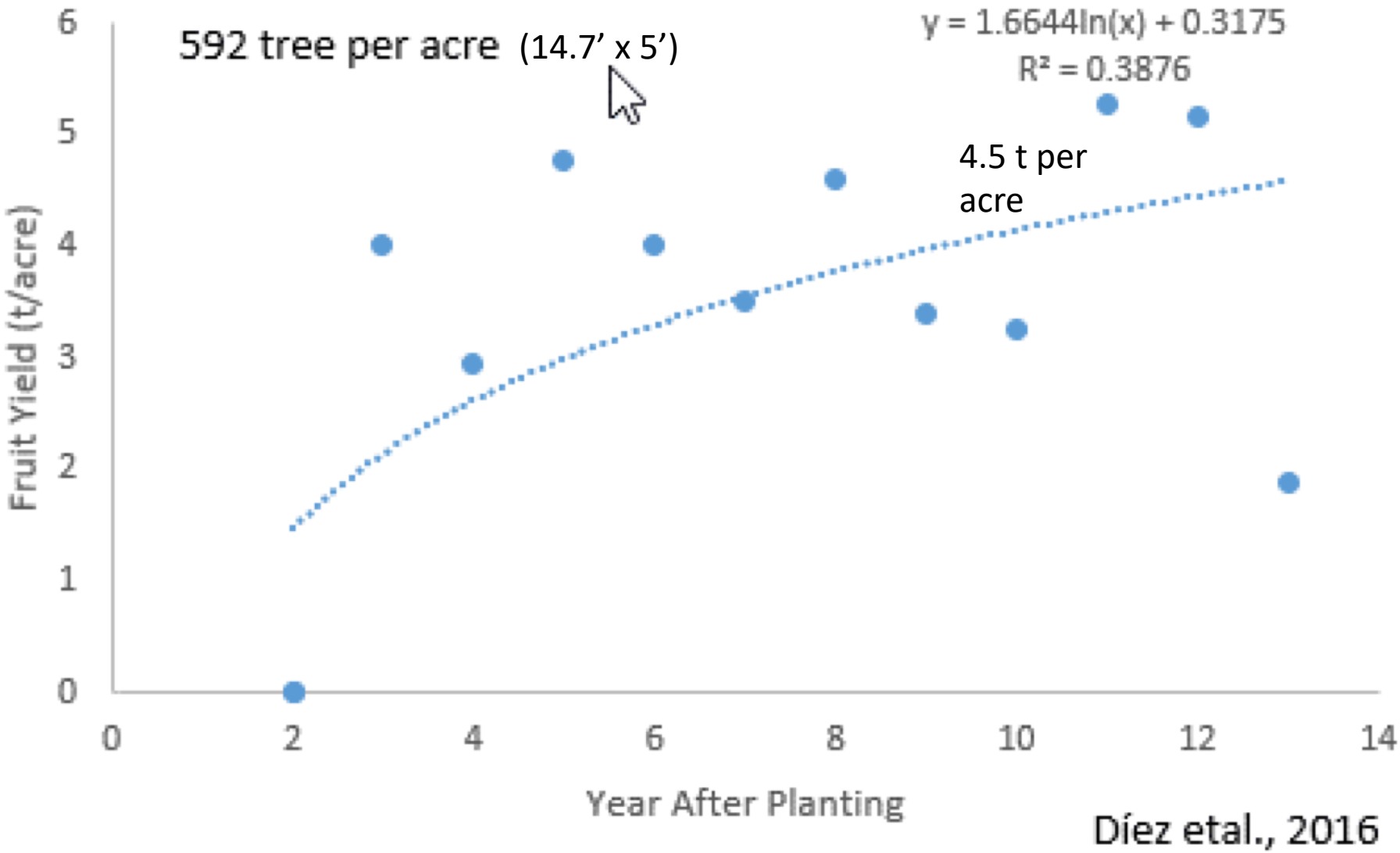
1. Light Models on Canopy Mgt
2. Varietal effects on Canopy Mgt
3. Light effects on fruit and shoot growth
4. Mechanical pruning timing, severity, frequency
5. Regulated deficit irrigation effects
6. Summary



Simulation of production in a superintensive olive grove with a density of 670 plants per acre (13 x 5 ft). Source

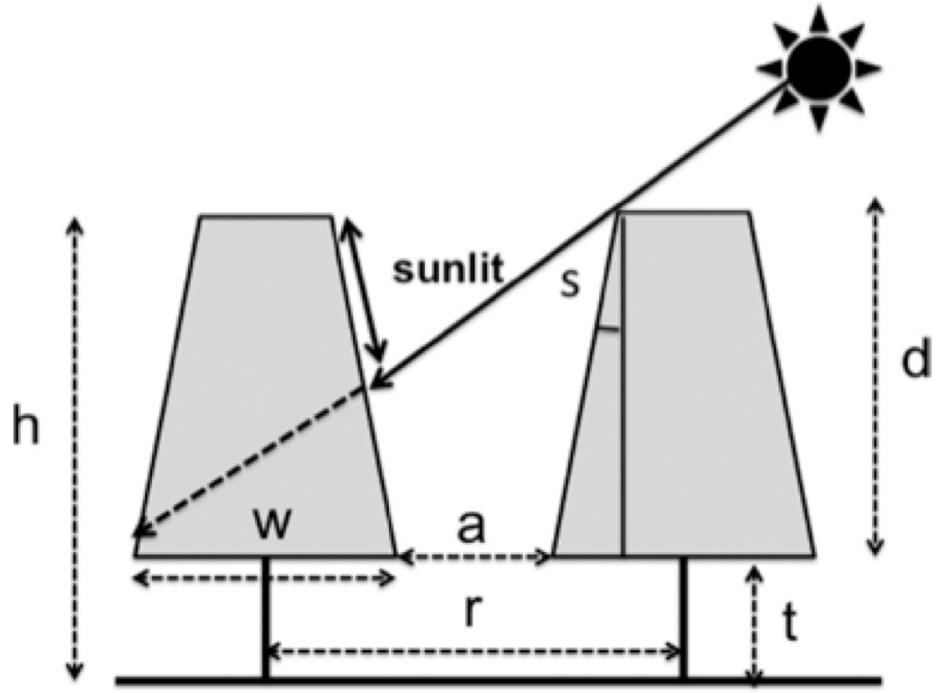
Source: De Benedetto, 2006. *» Yield verified from Bellomo et al .,

Arbequina yield data 14 years in Spain



Díez etal., 2016

Olive Production Model (Connor et al.,)



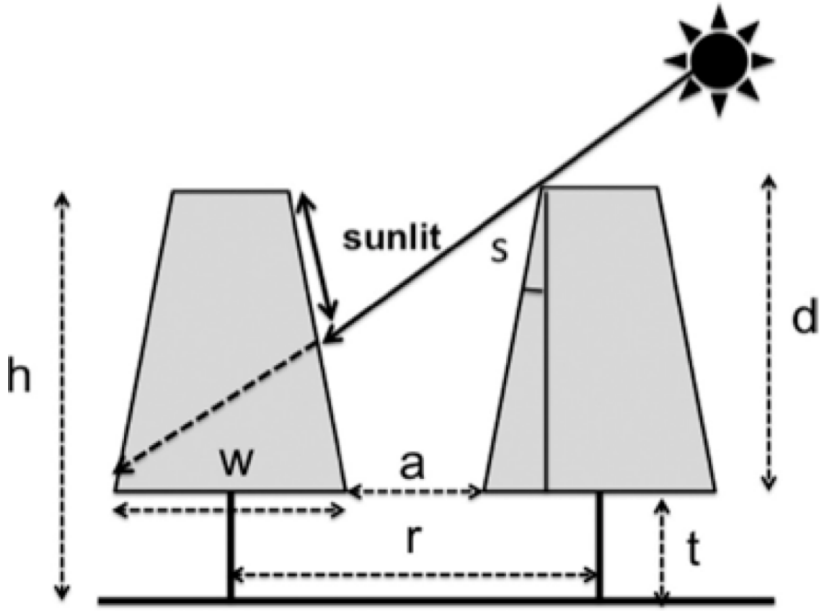
- Slope on canopy increases sunlit area on canopy wall
- Improved illumination allows for closer row spacing
- More applicable to high density

Simulation of yield and oil quality as affected by canopy depth, width, shape and row spacing.

Uses a model of illumination of hedgerow orchards and associated data on yield and oil quality collected from a range of SHD orchards of the variety Arbequina in Spain,

Model

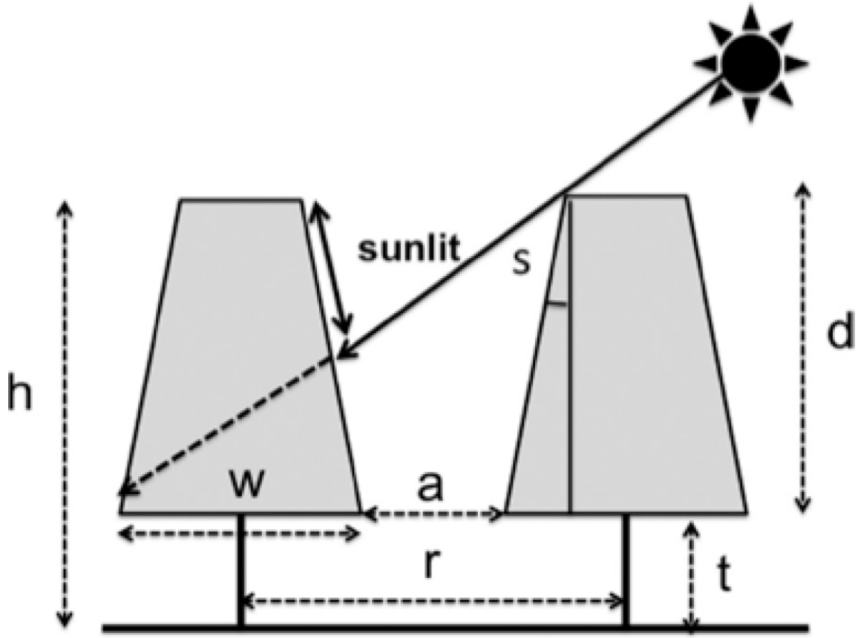
- Model functions between 30° and 40 ° latitude
- Yield is a function canopy depth and between row spacing. Maximum yield when alley width = canopy depth
- Closer row spacing increases yield because it increases row length per area.
- Closer in row spacing increases early but not mature yield
- Not applicable to east west plantings. Connor et al 2009.



a = d

Model Concerns

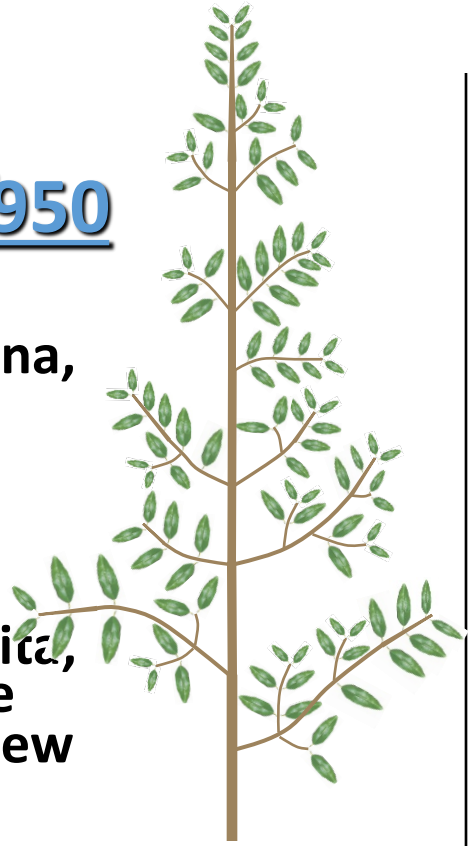
- Some research has shown highest yields corresponds with a D/A = 2 (Dietz, 2016)
- Model assumes most of fruit on the outer canopy, which may not be true for some varieties (Trentacoste, 2018)



Varieties Based on System

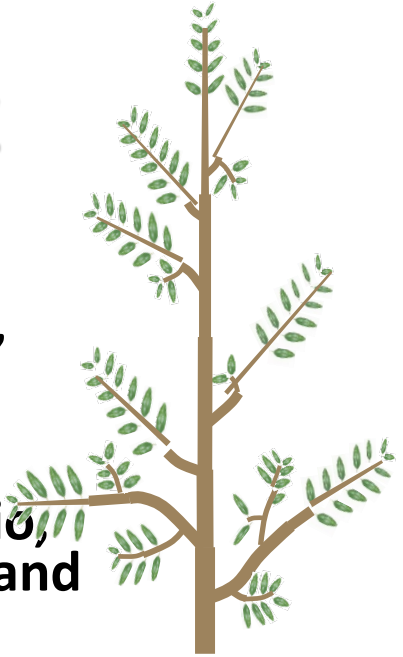
Super-High Density (600-950 trees/a)

- Arbequina, Arbosana, Koroneiki
- I-77, Don Carlo, Favolosa, Diana, Urano, Askal, Sikitita, Maurino, Charmille AJ-17,Oliana and new varieties
- Did poorly on trials- FS-17, Tosca



High Density (100-350 trees/a)

- Arauco, Manzanillo, Coratina, Picual, Barnea, Frantoio, Hojiblanca, Correggiola, Frantoio, Leccino, Nevadillo, and many more

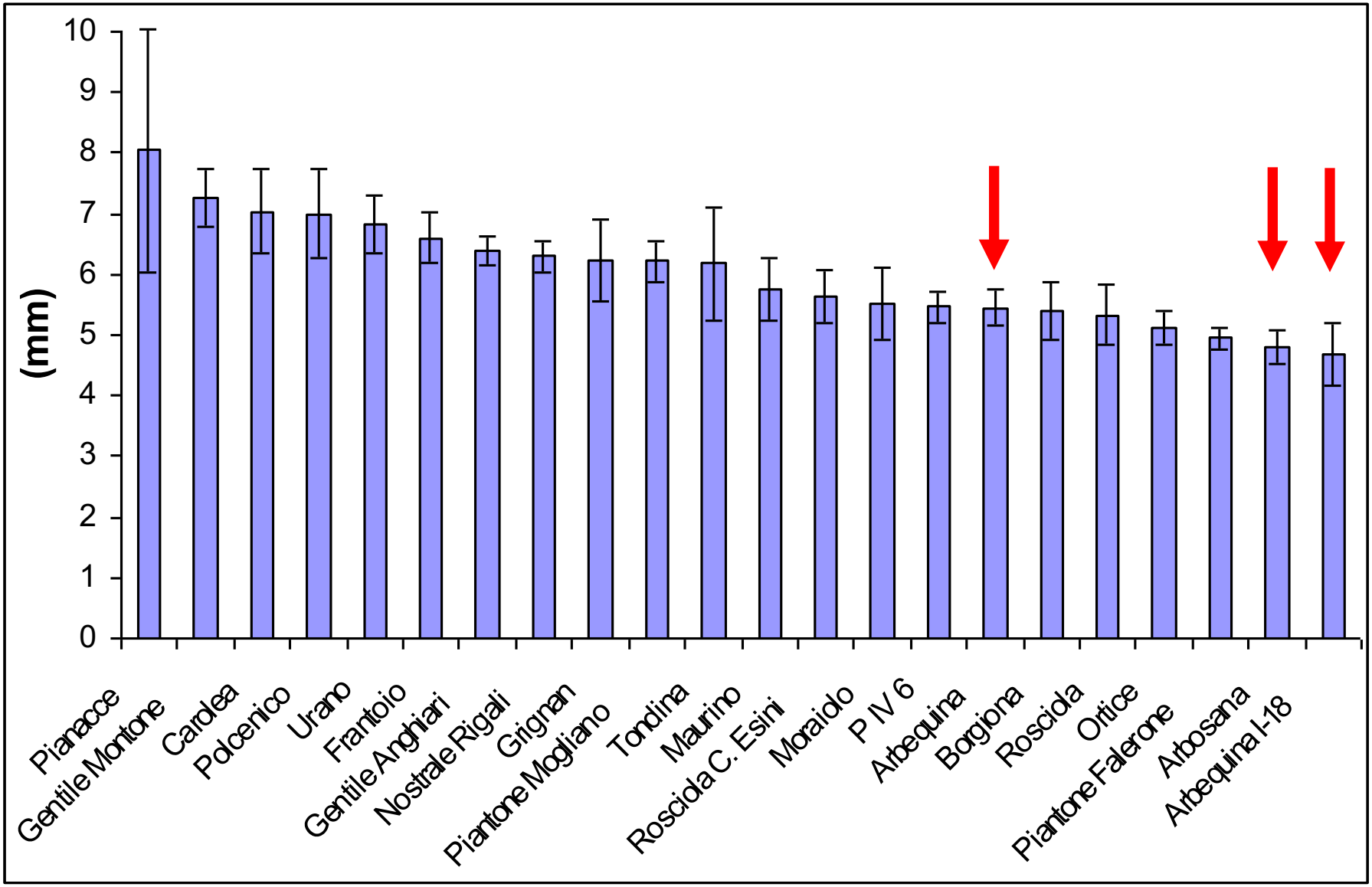


Marino et al., 2017

Rosati et al., 2013

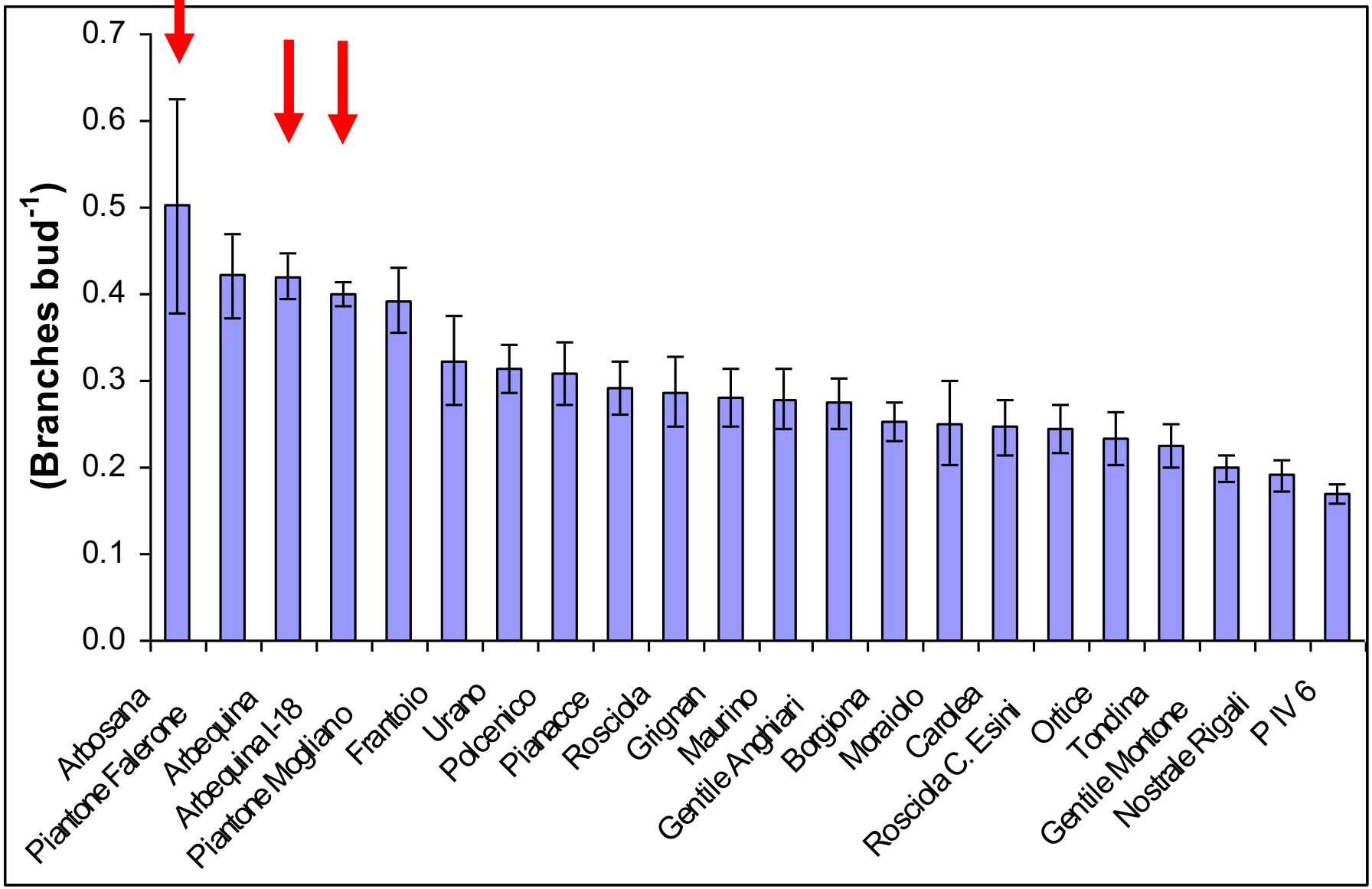
Gómez-del-Campo etal.,2010

Branch Basal Diameter



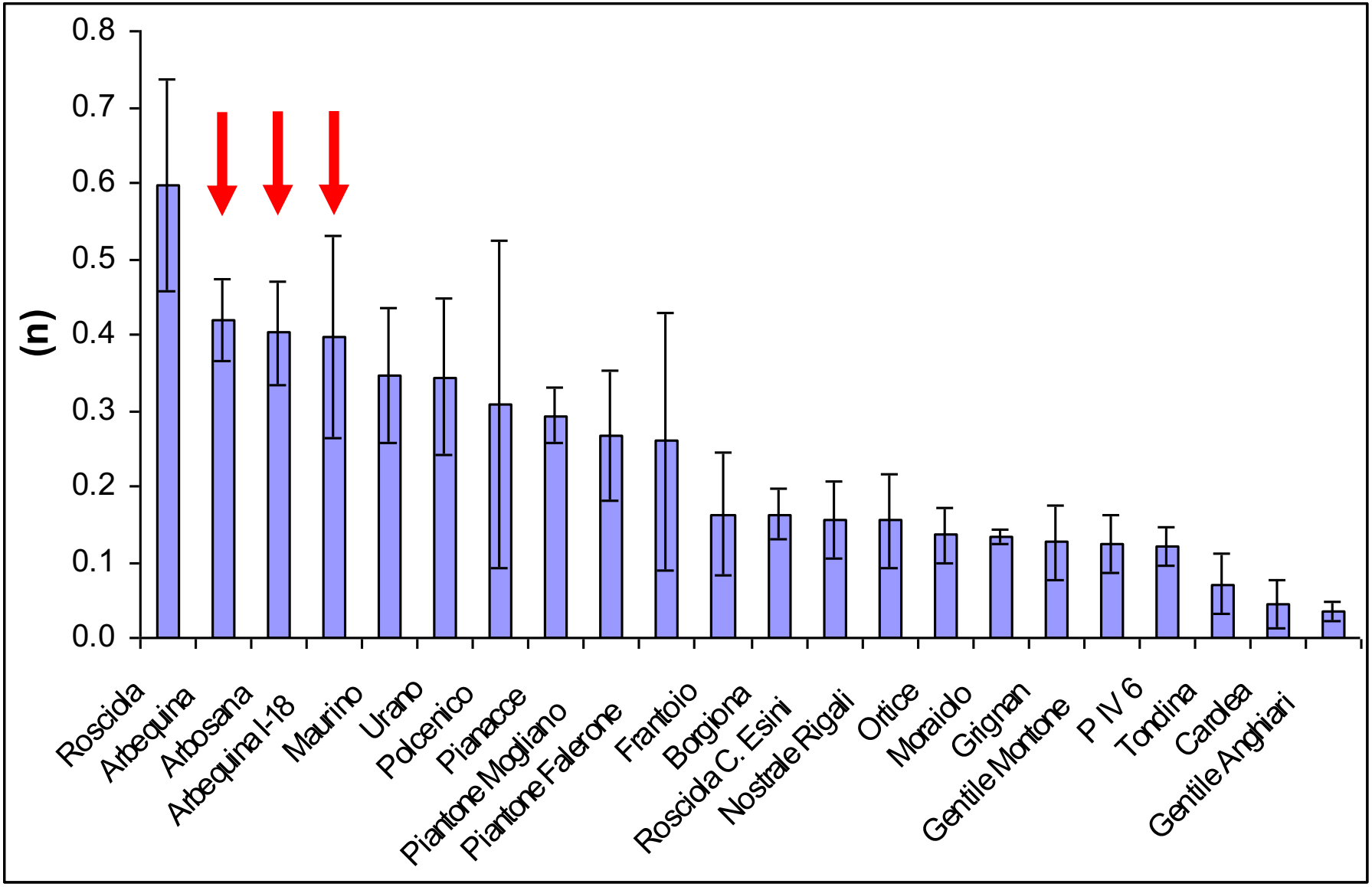
Rosati et al., 2013

Branching Frequency



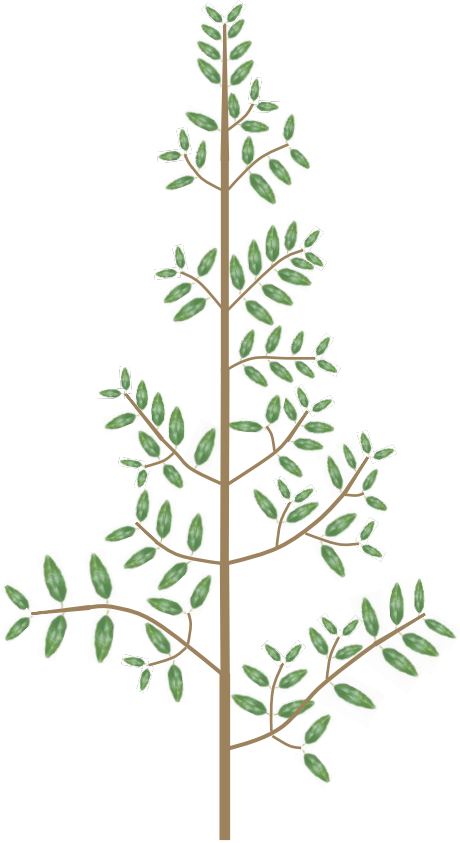
Rosati et al., 2013

Fruits / Node

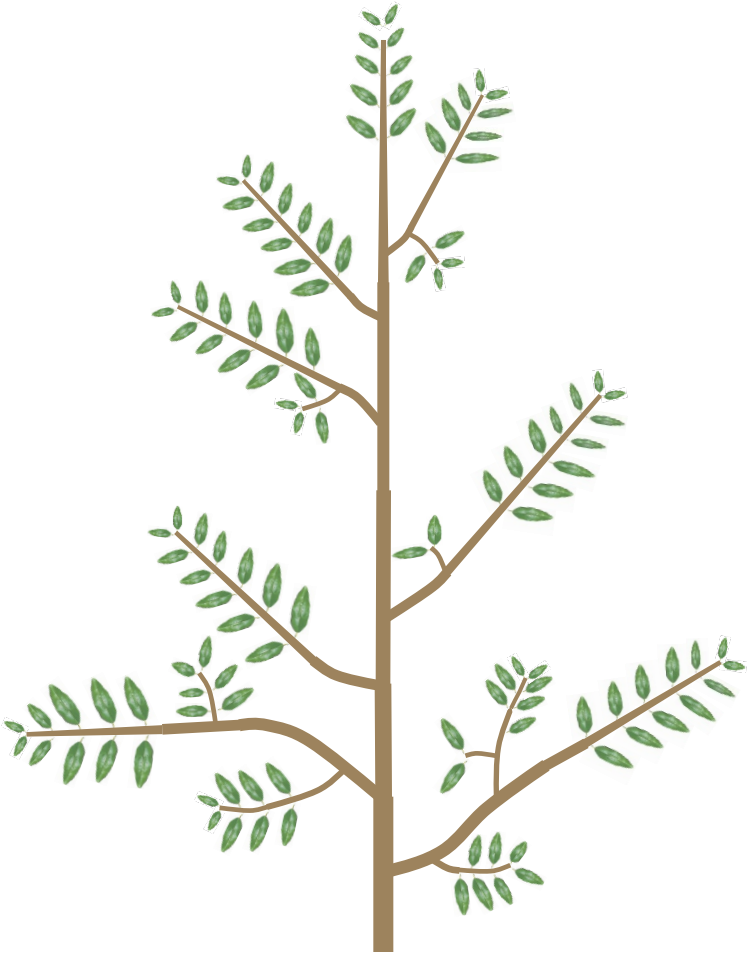


Rosati et al., 2013

Visual summary



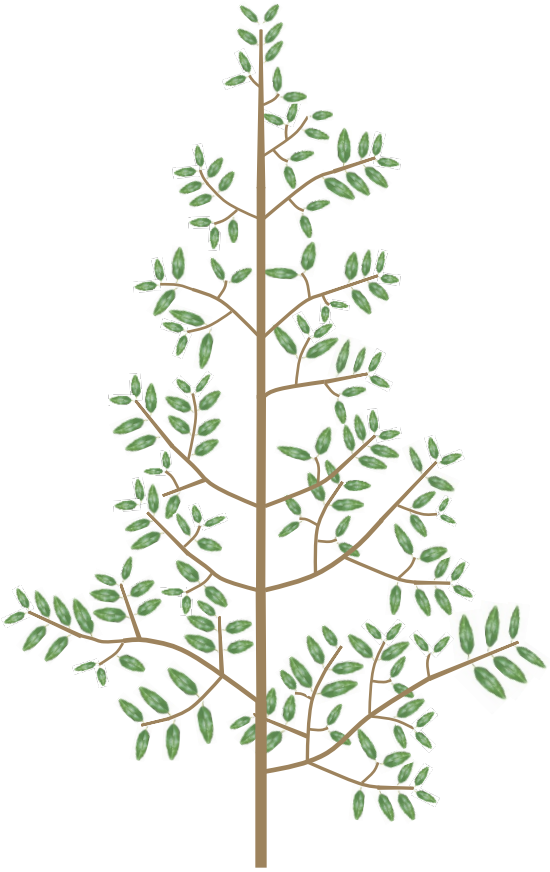
Arbequina



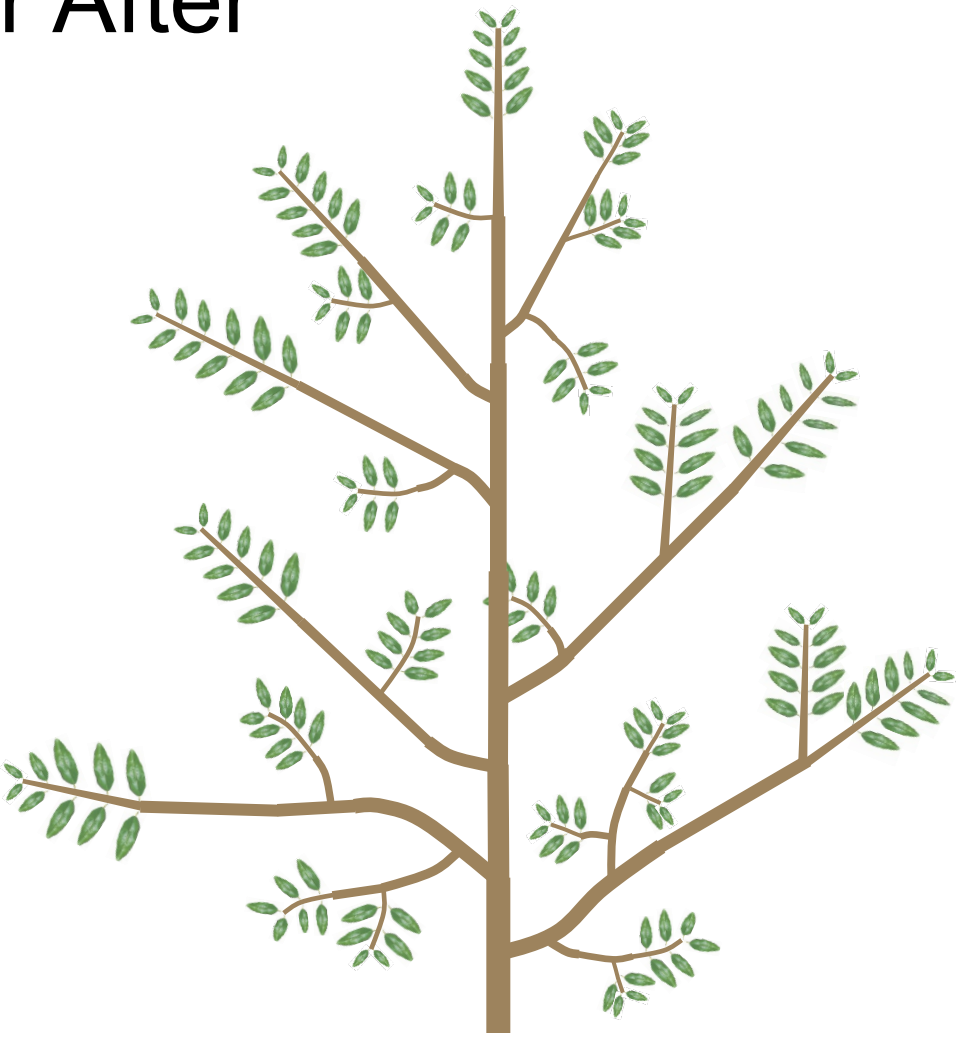
Other cultivars

Not suitable for SHD

A Year After



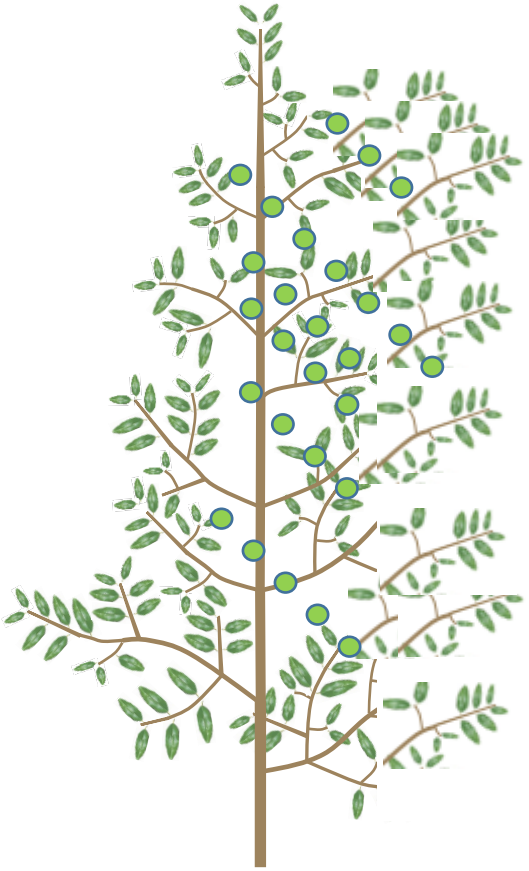
Arbequina



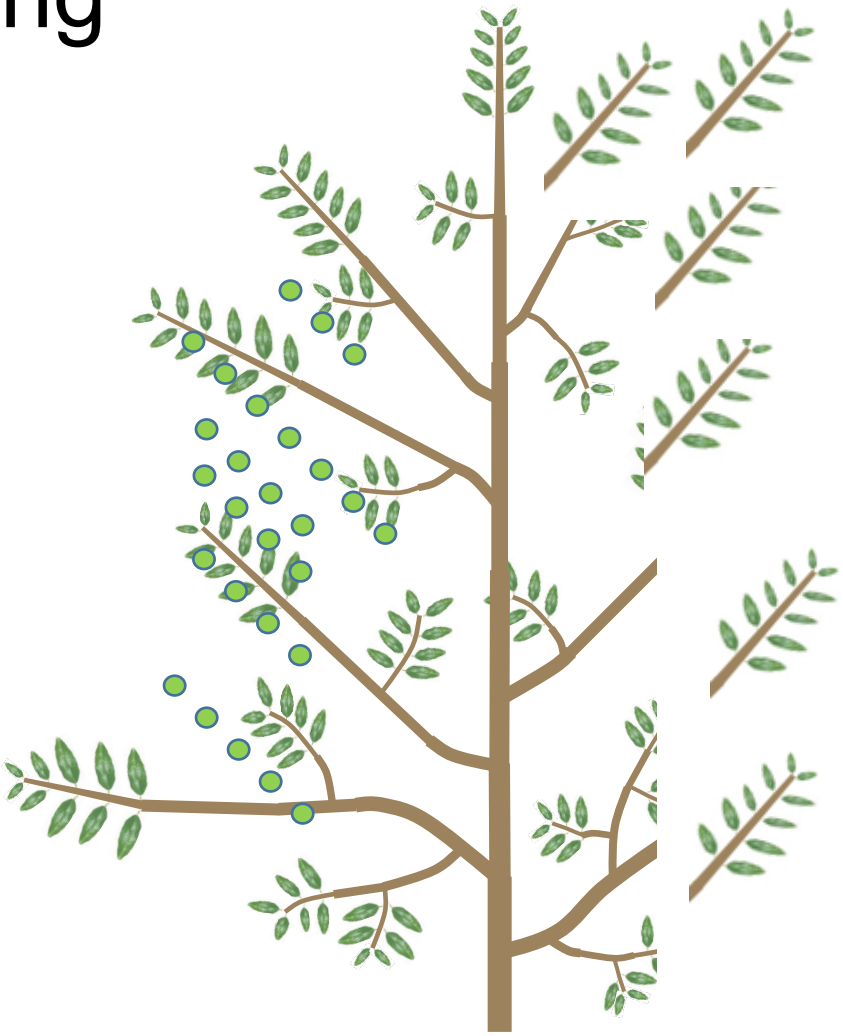
Other cultivars

Not suitable for SHD

Hedging



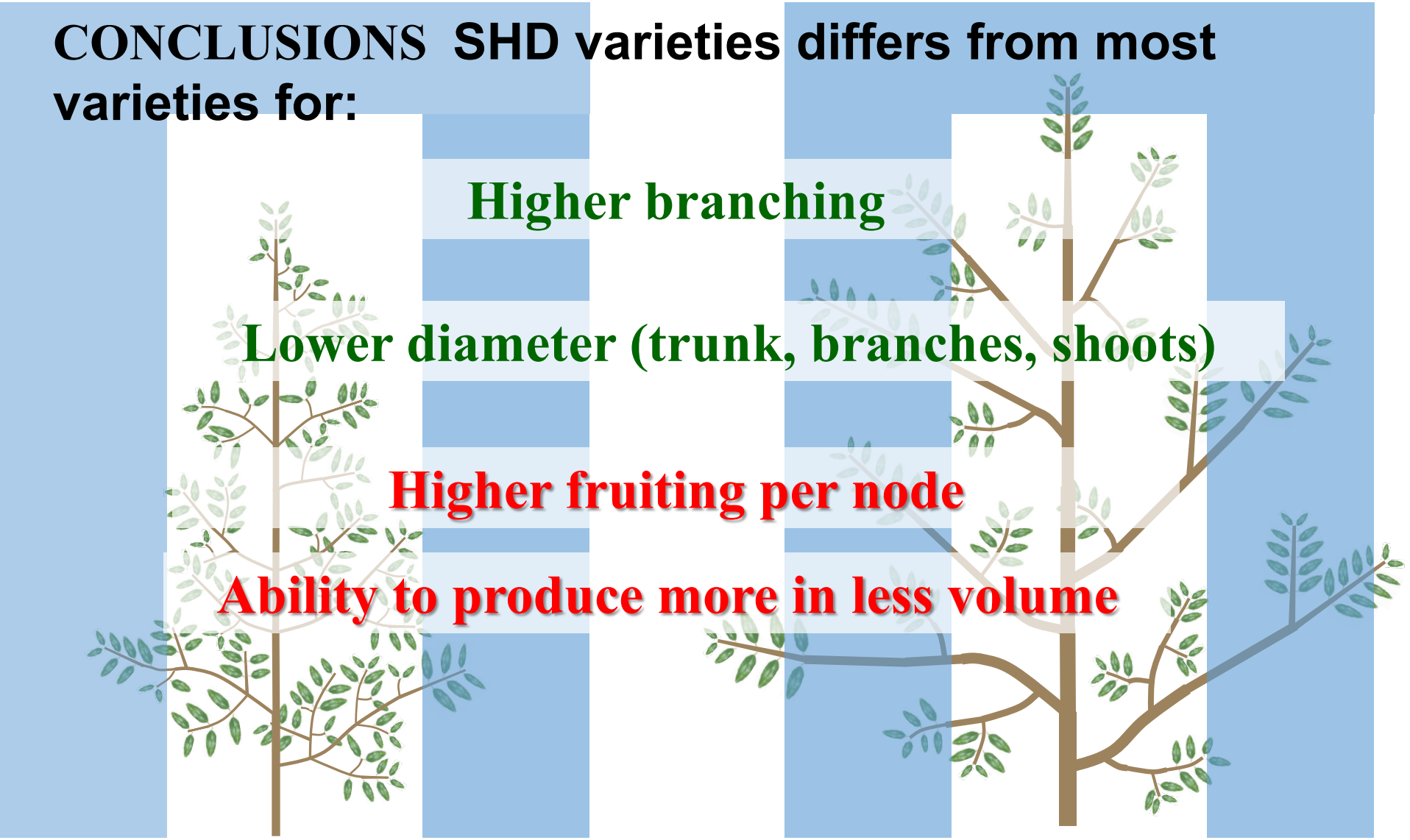
Arbequina



Other cultivars

Not suitable for SHD

CONCLUSIONS SHD varieties differs from most varieties for:



Higher branching

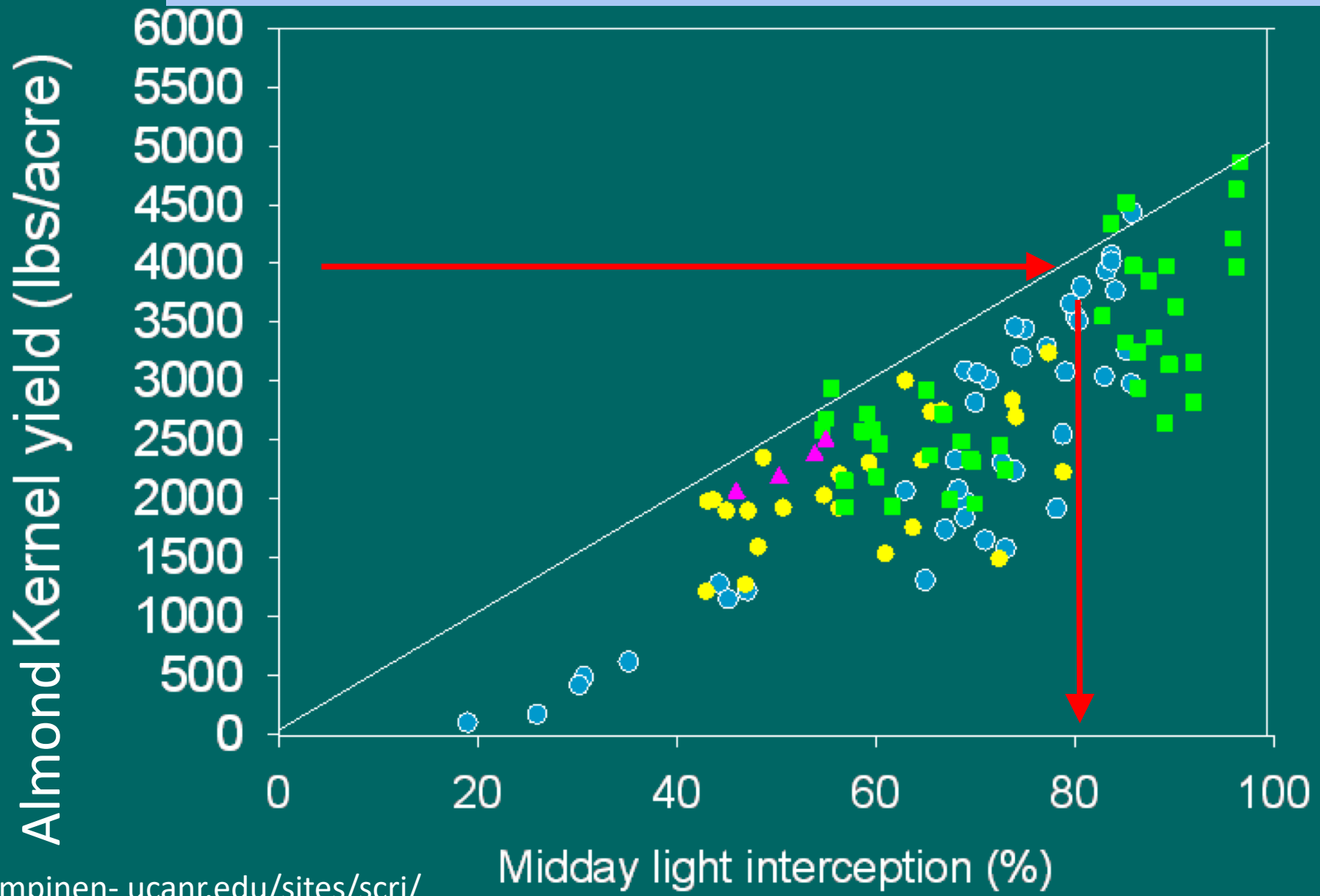
Lower diameter (trunk, branches, shoots)

Higher fruiting per node

Ability to produce more in less volume

Useful for variety choice and breeding

potential production = % PAR intercepted x 50 kernel lbs/a



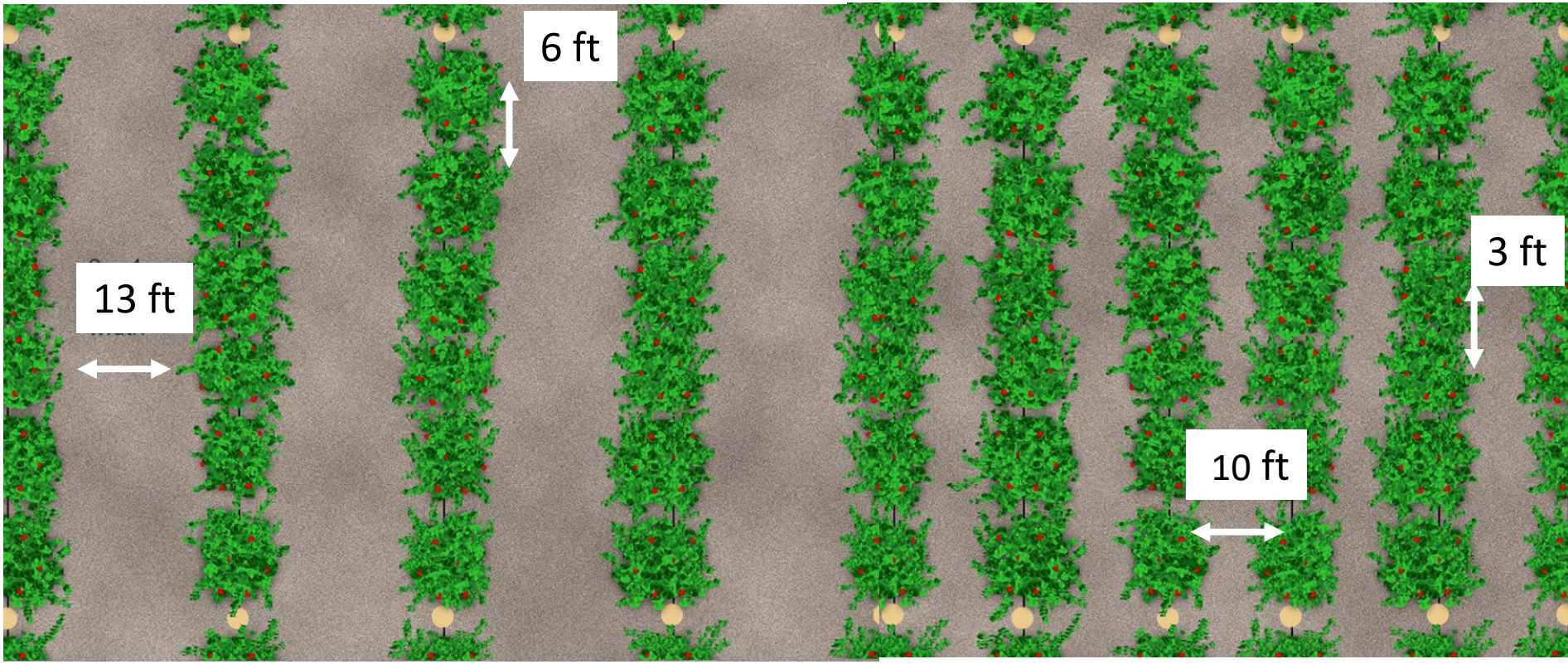
Lampinen- ucanr.edu/sites/scri/

At noon, light interception ~ 50 %. (~4-5 t/a fruit)

At noon, light interception ~74-84 %. (~10.7 t/a fruit)

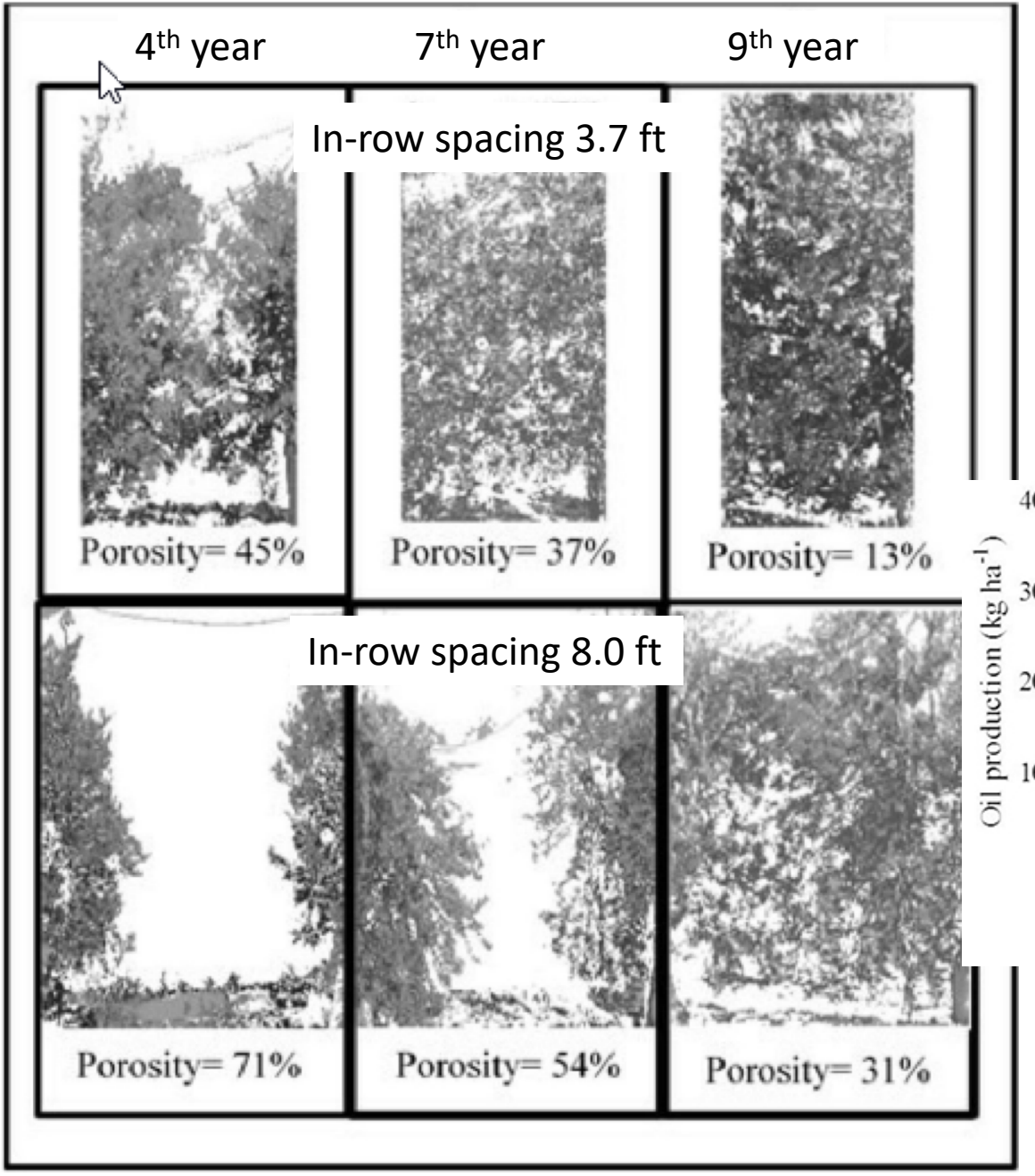
Increase light interception by:

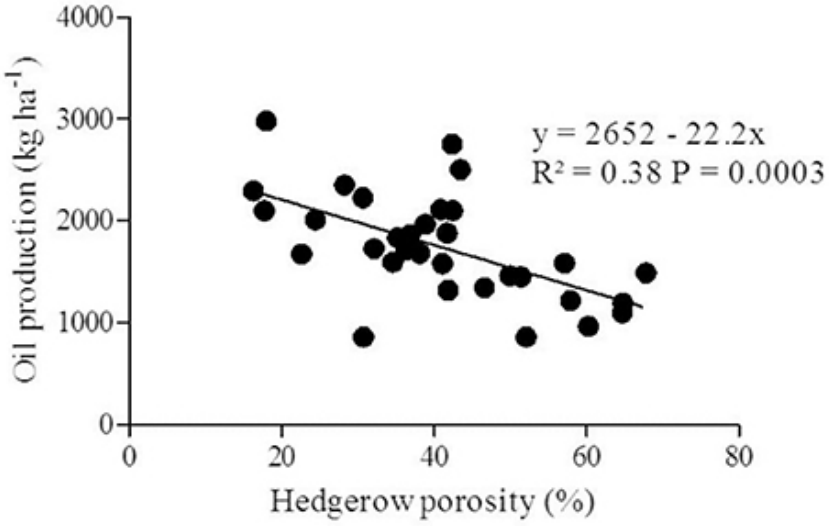
- Decrease in-row spacing
- Decrease between-row spacing (alley width)
- Increase tree height



Arbequina

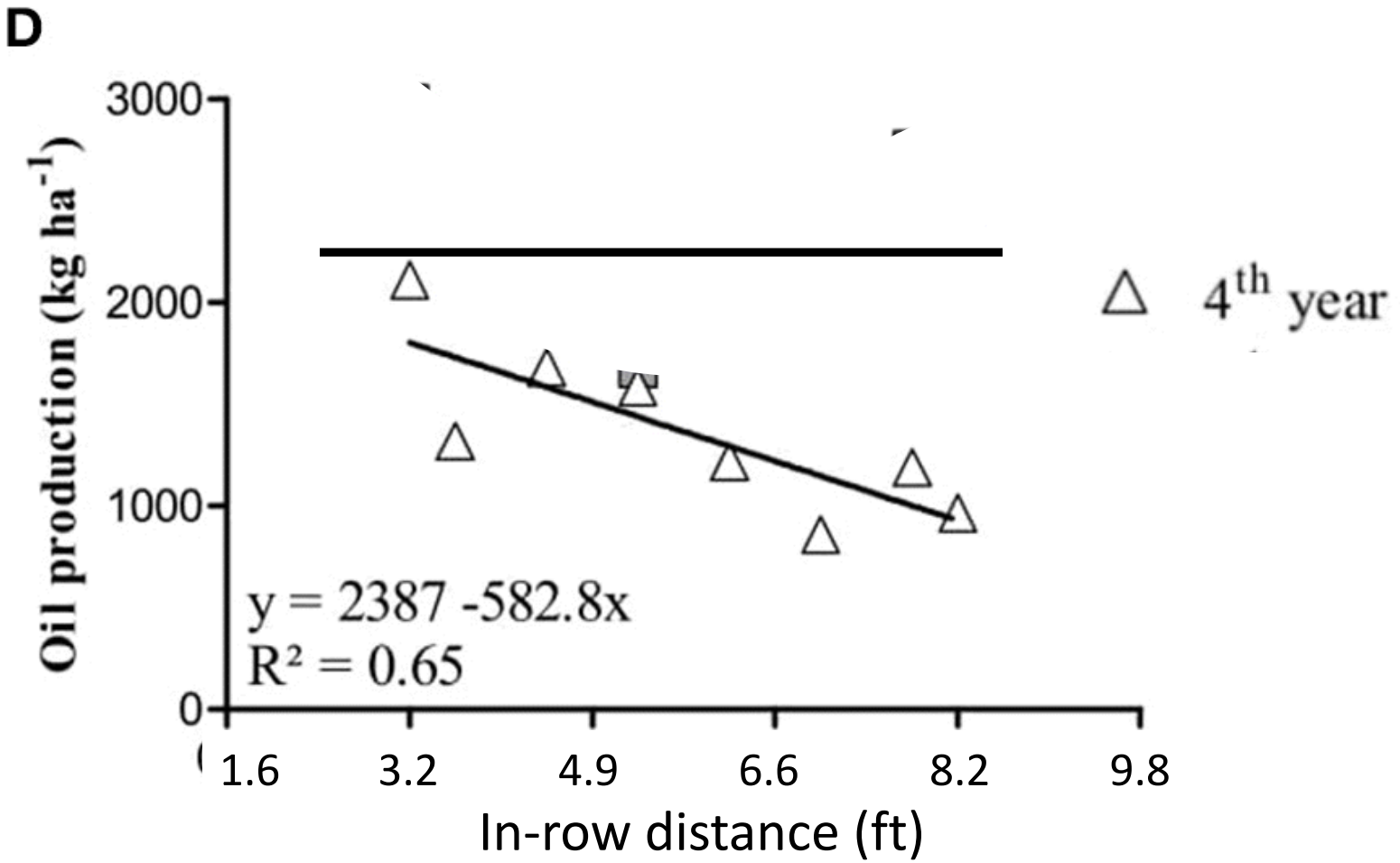
In-row Spacing



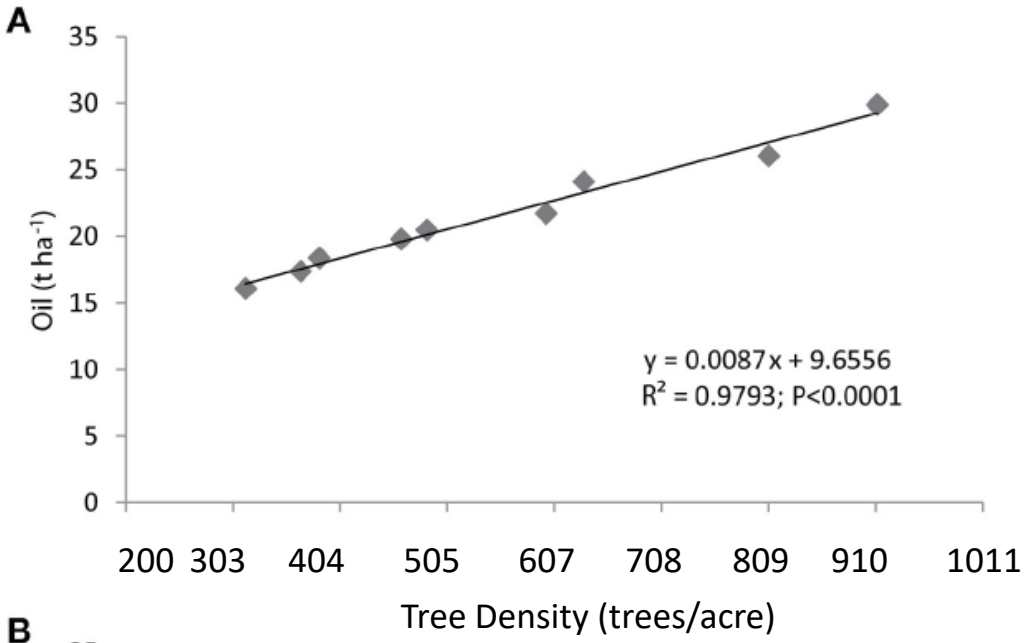


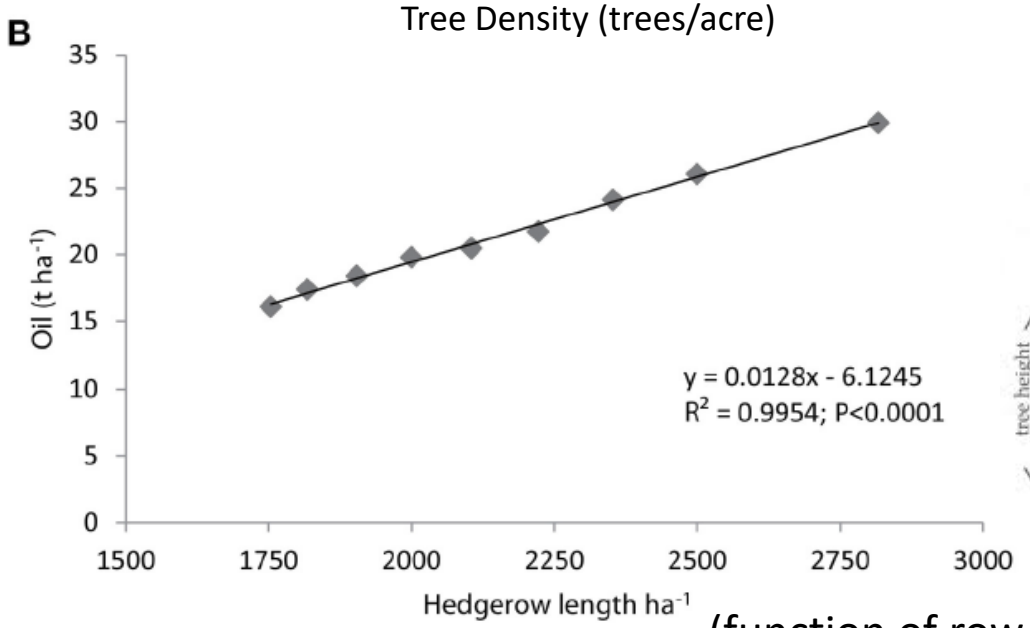
Maria Gomez-del-Campo et al., 2017

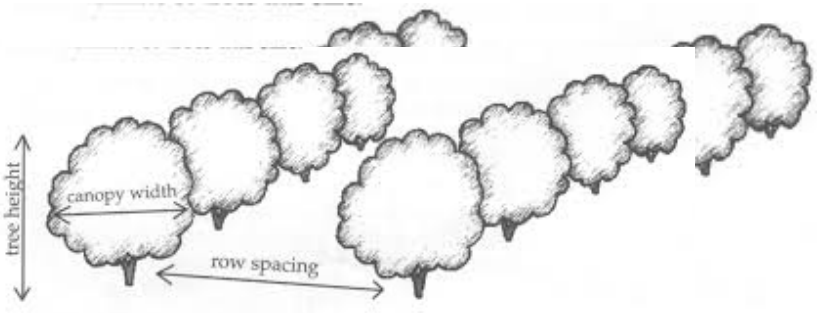
Effects of in-row spacing on oil yield



Gomez-del-Campo, et al., 2017







(function of row spacing)

FIGURE 2 | Linear regression of accumulated oil per hectare over olive tree density (A) or the hedgerow length (B) over 14 years after planting the cultivar "Arbequina."

Díez et al., 2016

How
enou

South Side

2 m

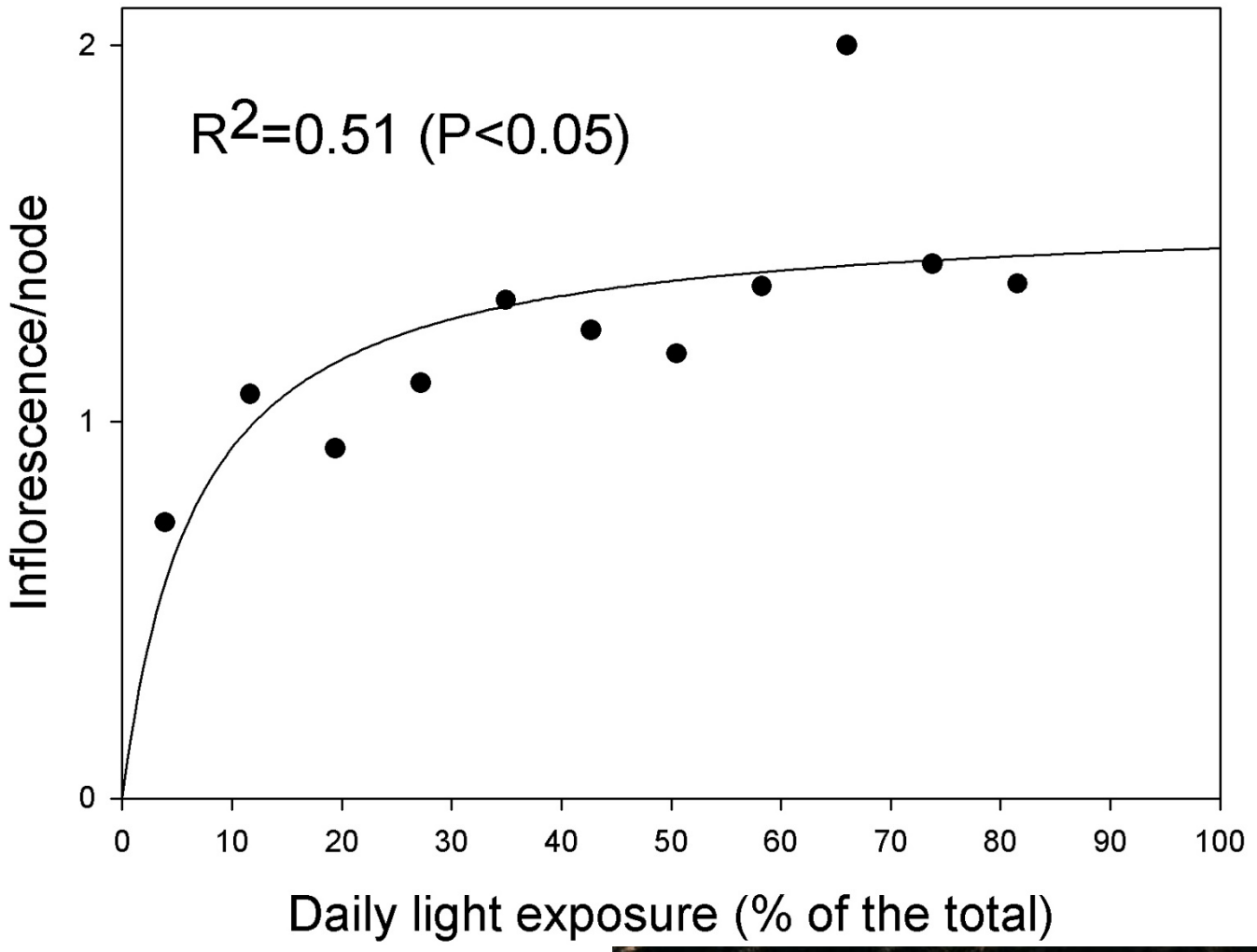
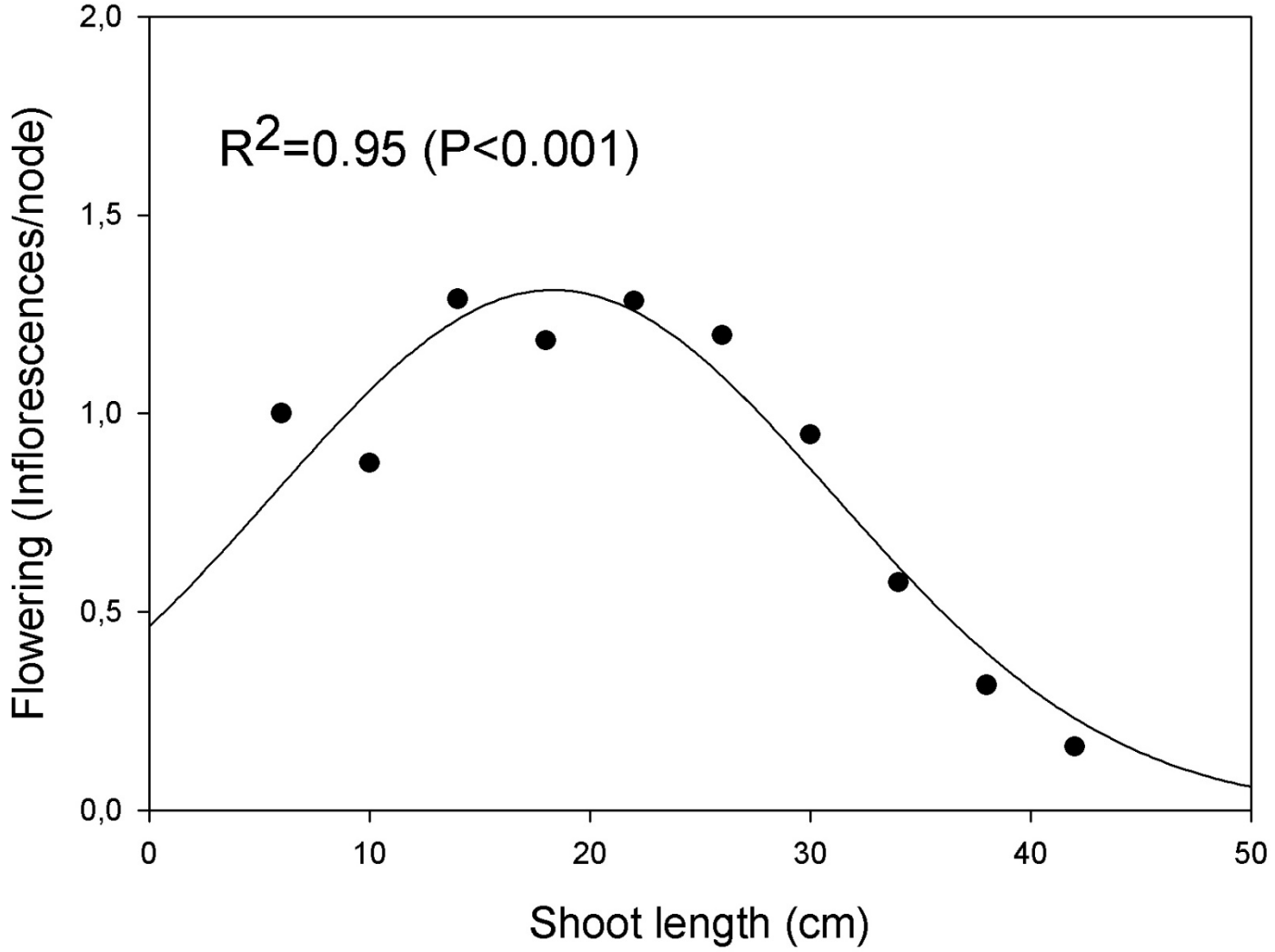


Fig. 1. Dia

In Cherbiy-Hoffmann, et al., 2013.

Maurino



Tombesi and Farinelli, 2011

Hedging to Maintain Trees Size for Mechanical Harvest

Two studies have recorded the effect of simultaneous mechanical hedging of both sides of olive hedgerows (Albarracín et al., 2017; Vivaldi et al., 2015).

1. Oil yield ↓ in the current season recovered the following season. Over three years cumulative oil yields were equal for hedged and unhedged.

2. Hedging and topping ↓ oil yield for 3 years in high- but not in low-vigor cultivars (e.g. Arbequina and Arbosana), low vigor varieties with fruiting near the trunk.

Alternate year hedging maintained hedge row dimensions and oil production in two successive growing seasons. (Trentacoste et al 2018).

Simulated heavy hedging cutting into older wood (3 to 4 years) resulted in vigorous water sprouts with limited flowering which took up to 3 years to return to production (Albarricin et al. 2018).

Comparison of Mechanical Hedging Regimes for Super High Density Oil Olives, 'Arbequina' Cultivar

WH. Krueger[1] R. Rosecrance[2], A. Rosati[3], L. Milliron[4], A. Englehardt[5], B. Mori[5], C. Garcia[5] and J. Post[6]

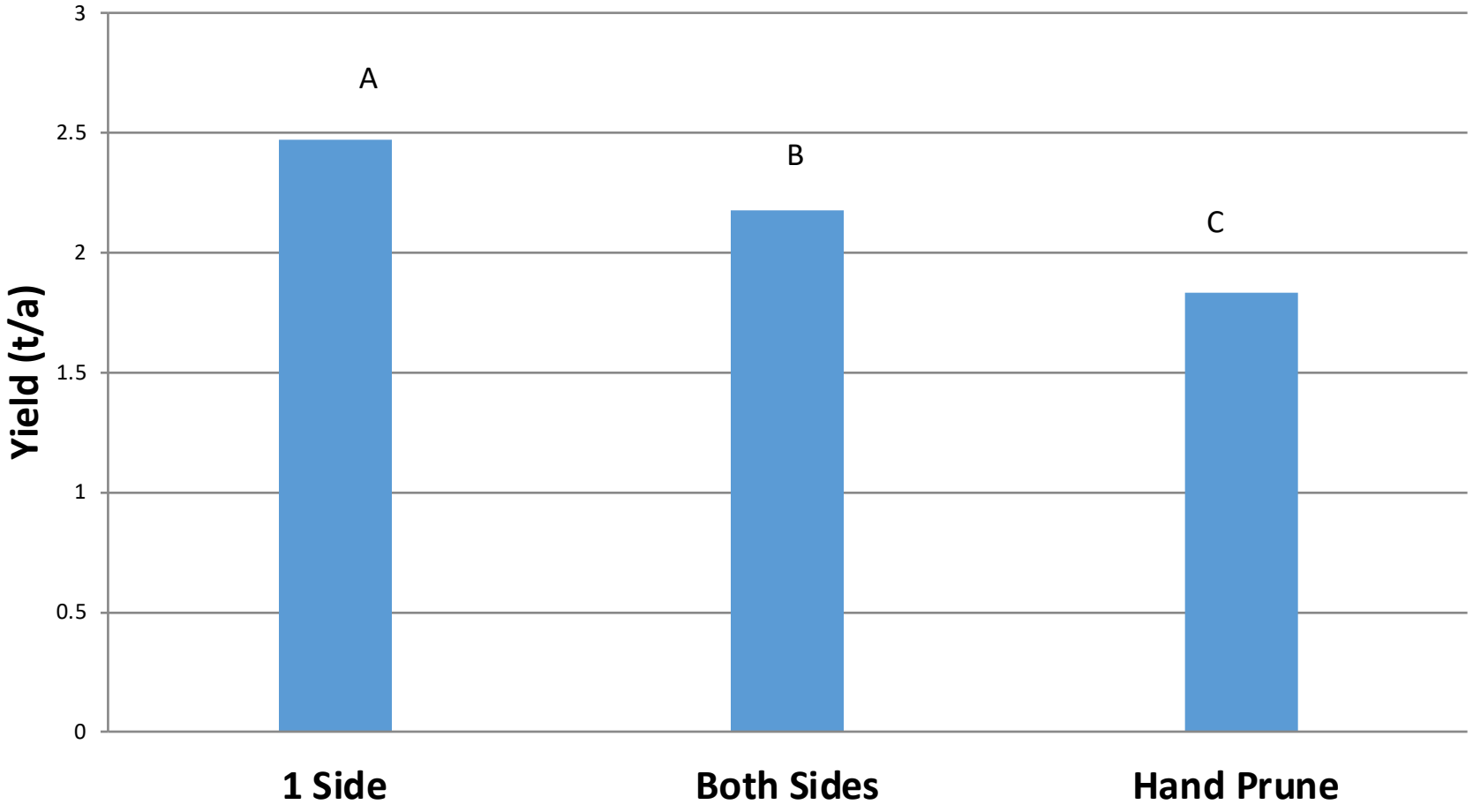
Hedging one side of 2 rows (22-24 inches from center)

Hedging two sides of one row (22-24 inches from center)

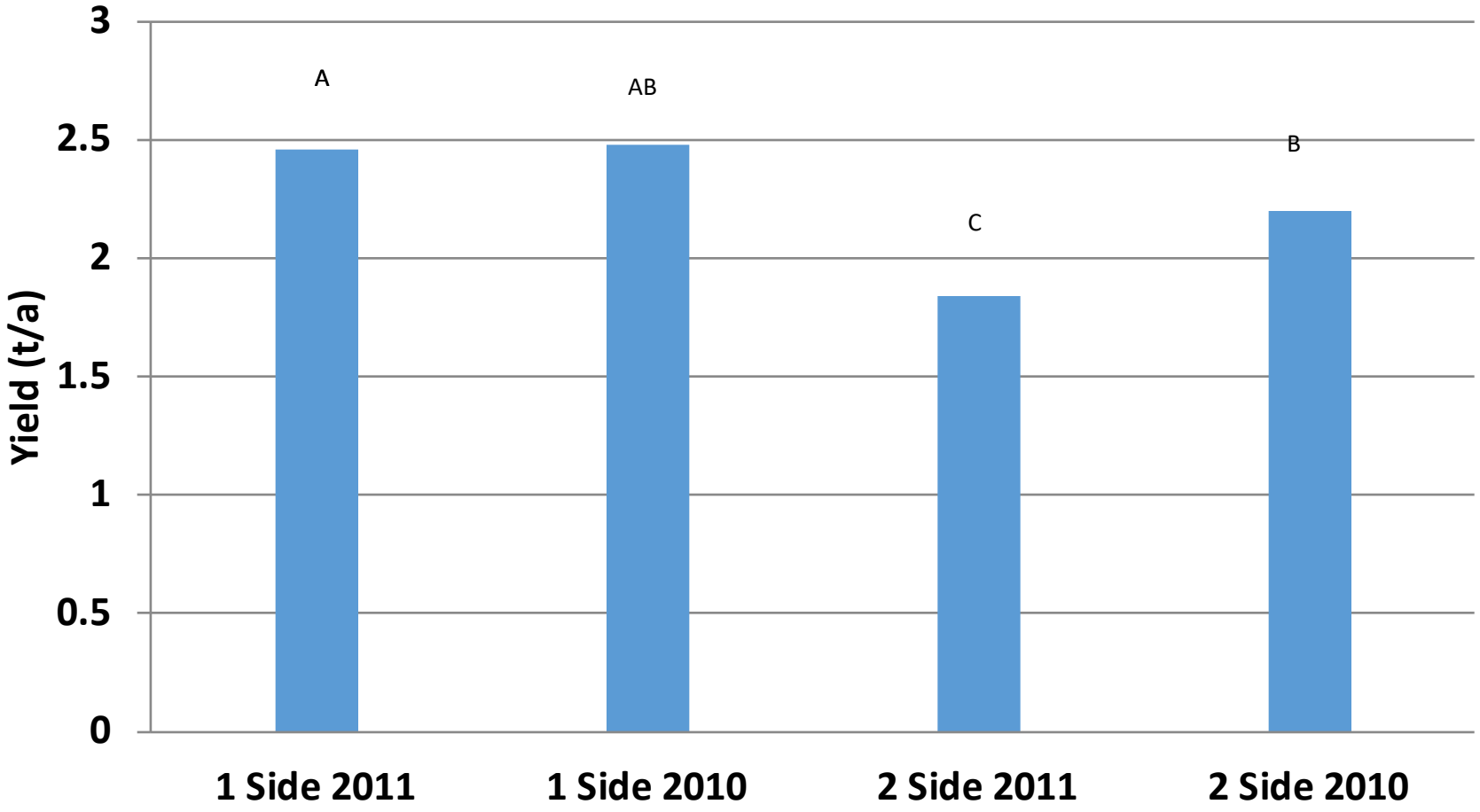
Hand pruning, annually

No pruning- for 3 years

2011 Yields for Four Row Blocks



2011 Yields from Pruning Treatments in 2010 and 2011



Results

- Hedging did not significantly reduce yields in 2010 or 2012.
- One side hedging did not significantly reduce production in any year
- Hedging spurred vegetative growth, but hedging both sides resulted in significantly smaller canopy diameters and reduced yields
- Hedging may keep the productive area closer to the center of the tree and improve harvest efficiency

Additional Research Needs

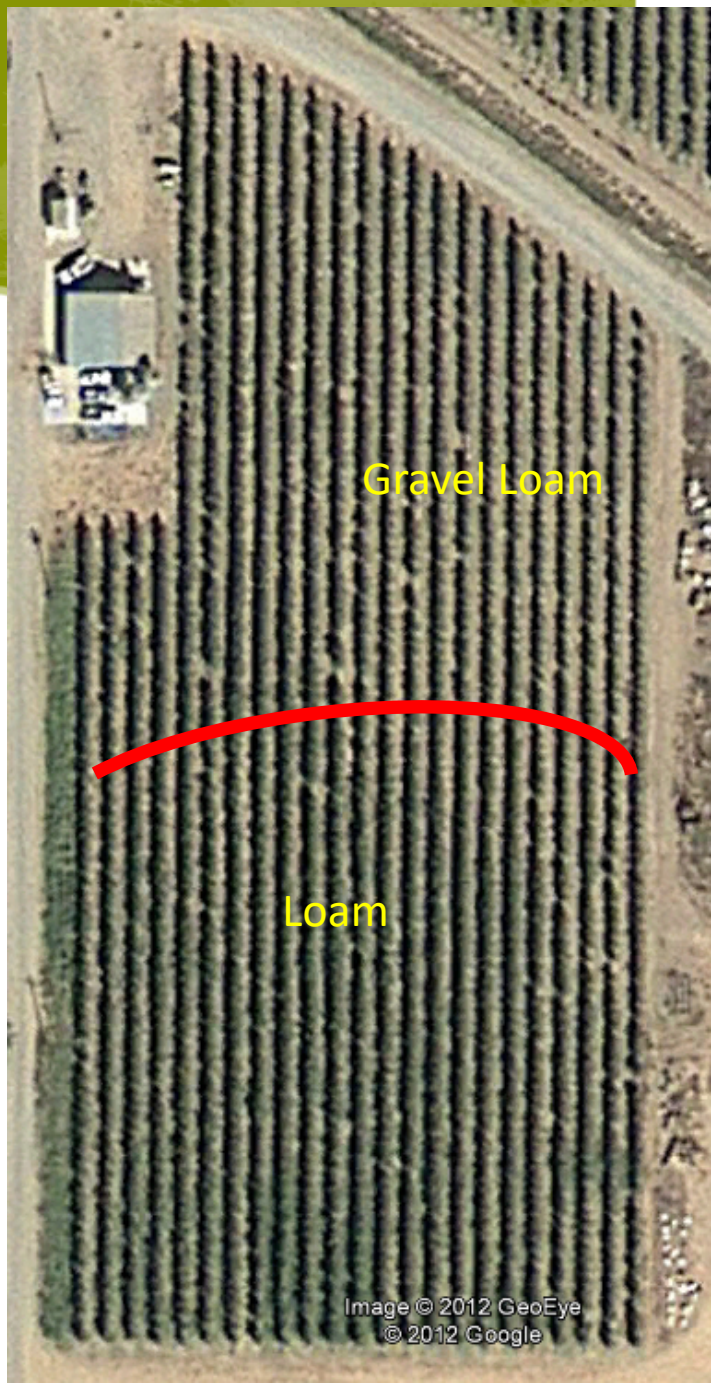
- Must be able to maintain tree shape and size suitable for mechanical harvest without excessive shading or pruning resulting in vigorous non productive growth.
- Timing of mechanical pruning - optimum use of summer pruning especially topping to reduce vigor without loss of yield. Only 1 study looked at severe summer pruning which reduced growth but drastically reduced yield (Albarracin et al. 2017).
- Effect of time of pruning on return bloom
- Frequency of pruning- alternate year, or a 3 or 4 year cycle etc.
- Varietal response to hedging and topping

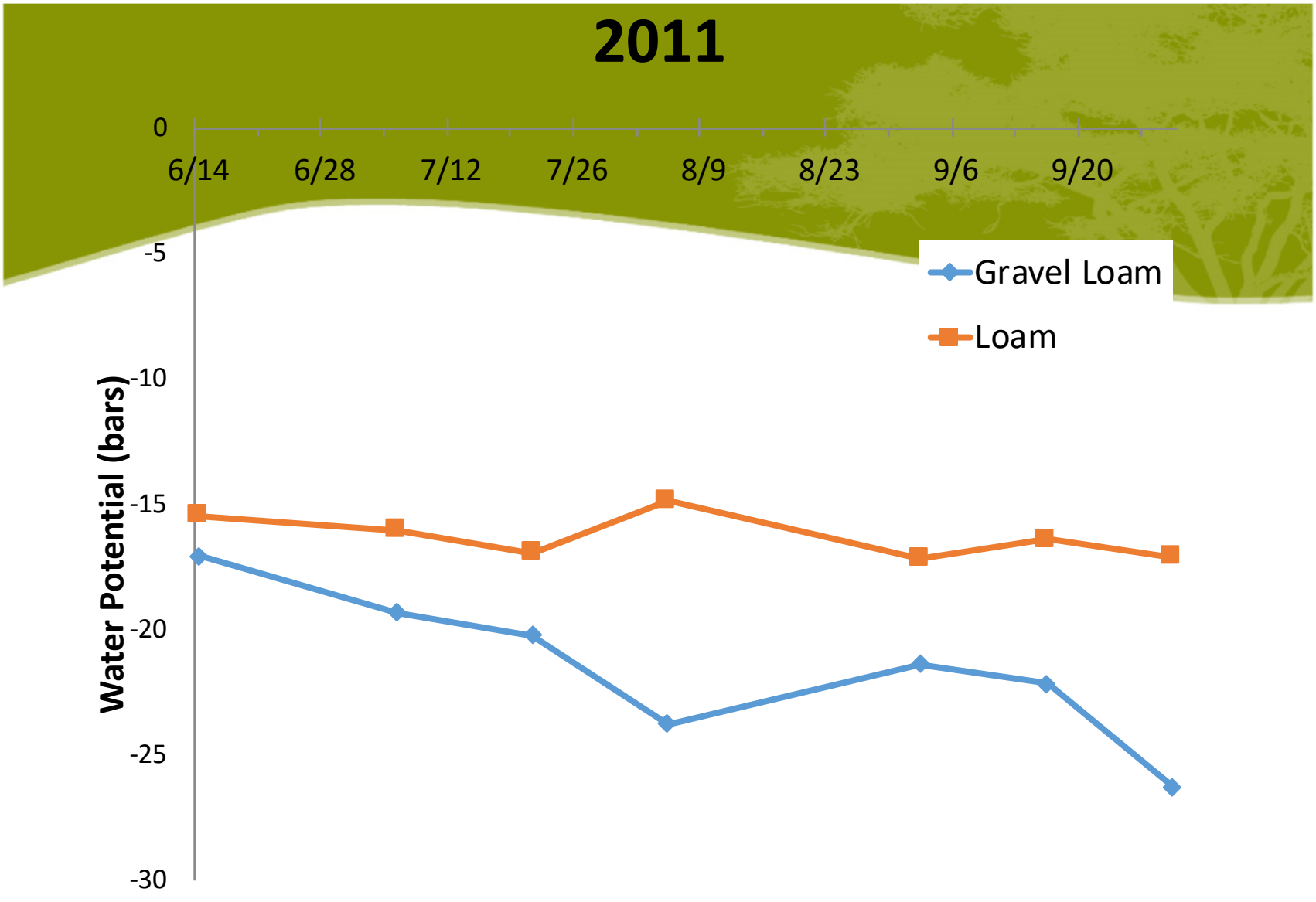
Using RDI to Control Vigor

- Regulated Deficit Irrigation (RDI) has been shown to reduce vegetative growth without reducing yield or quality (Rosecrance and Krueger et al, 2015, Caruso et al 2013, Hernandez et al
- Stem water potential can be used for RDI

RDI Plot

- Mild Stress- loam soil -17 bars July to harvest
- Moderate Stress- gravelly soil -13 bars to mid July then -22 bars to harvest




2011
0
6/14
6/28
7/12
7/26
8/9
8/23
9/6
9/20
-5
-10
-15
-20
-25
-30
Water Potential (bars)
Gravel Loam
Loam

Moderate vs Mild Water Stress

- Earlier maturity 2.68 vs 2.0 maturity index
- Lower moisture levels and higher polyphenol content (33% greater)
- Increased oil yield- 12%
- Reduced vegetative growth- 36% less shoot growth
- Consensus forming from literature - 20 to -25bars from pit hardening to harvest to maximize yields and decrease growth.

Canopy Management Summary

1. Light Models on Canopy Mgt

   - D/A ~ 2 for max yield

2. Varietal effects on Canopy Mgt

   - SHD varieties ↓ shoot diameter, ↑ branching, ↑ flowers per node.

3. Light effects on fruit and shoot growth

   - fruit & shoot growth needed 30-40% light

4. Mechanical pruning timing, severity, frequency

   a. Alternate year hedging, avoid severe topping & hedging

5. Regulated deficit irrigation effects

   a. -20 to -25 bars pit hardening to harvest to maximize yields and decrease growth