

Spacing: What is the correct spacing and why?

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Wonderful Citrus

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View onto the Sierra Nevada from the San Joaquin Valley



Where WC grows: 23,000 hectares



Valencia



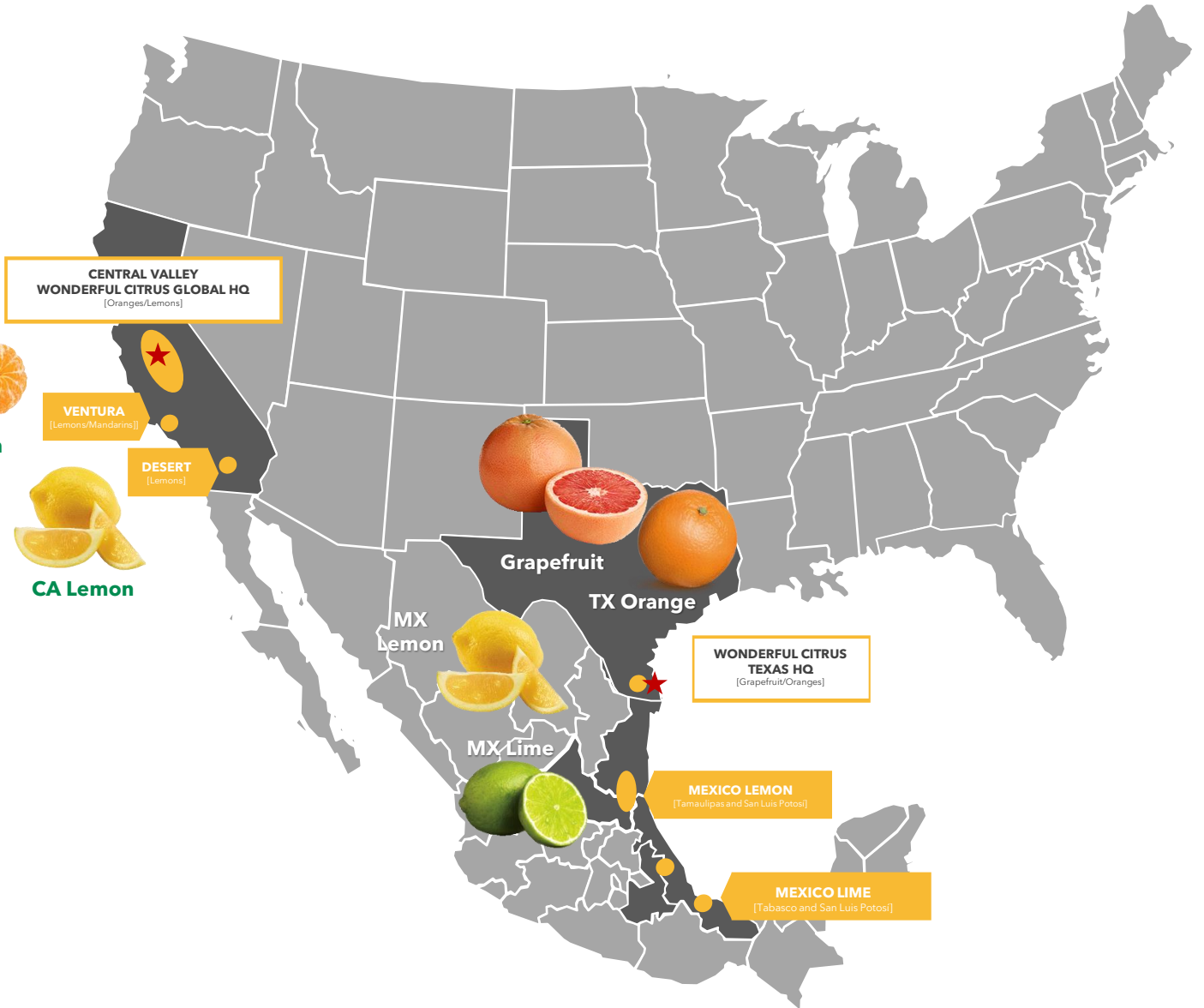
Navel



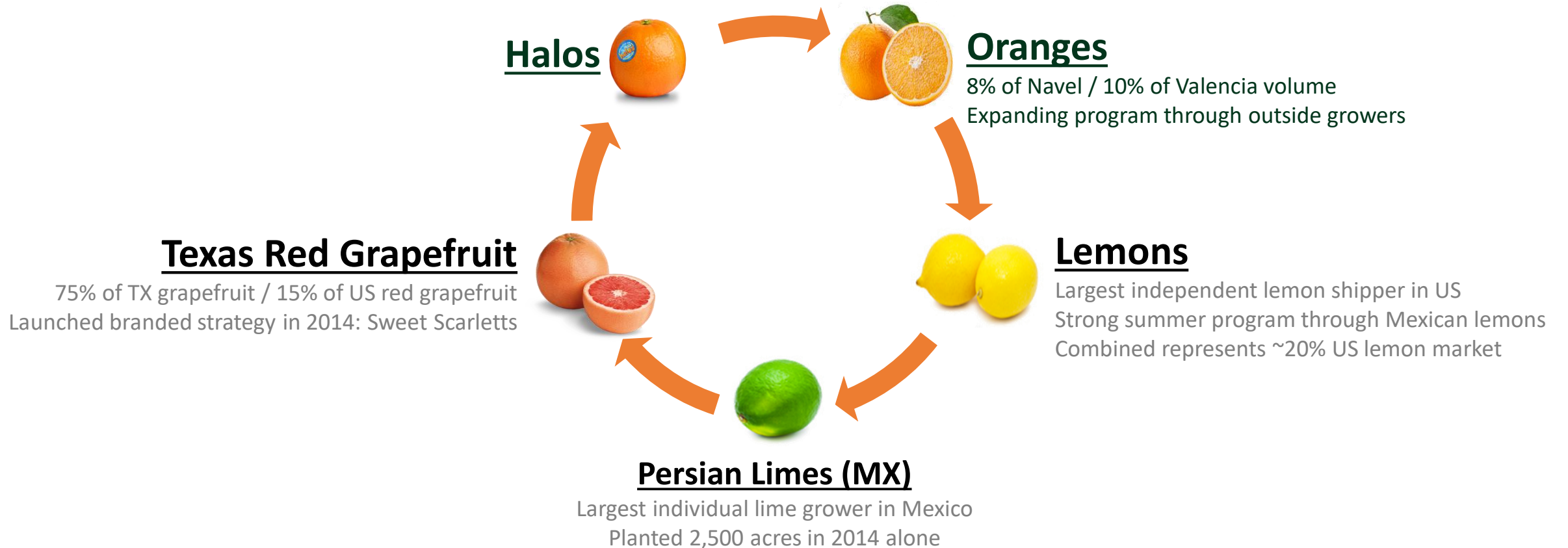
Mandarin



CA Lemon



Wonderful Citrus continues to grow as a one-stop shop for all major citrus varieties



Cuties: Established In 2004



Halos: Launched in Nov 2013

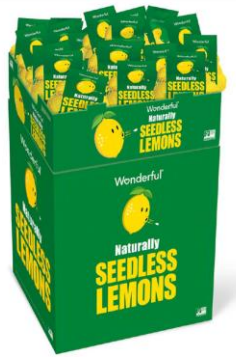


Seedless lemons: Launched in 2018



Wonderful is making exciting and important investments across channels to promote awareness

Bin Base



New Secondary POS Display

Produce



Seafood



Cocktail



External activations/competitions to engage & reward industry partners

Preamble: Realities facing many regions

- **Water** scarcity/costs
- **Labor** costs and availability (U\$15/day to U\$20/hour!)
- Increasingly expensive **input costs**: fertilizer and pest control chemicals [U\$2.5 K/ha to U\$10 to U\$13K!]
- **Regulatory/Environmental demands/Safety**
- **Variety changes**
- **Consumer trends**
- **Competitiveness eroding** for some regions! Margin compression unsustainable
- **Automation** becoming imperative in high cost environments

Spacing: general comments

- There is no **“right” spacing**
- Usually dependent on **grower philosophy** --- intensive vs extensive
- Spacing “definitions”
- If I **buy**: **wider spacings**; larger trees
- If I **plant**: **closer spacings**
- **Hedgerow configuration early** in orchard lifespan; best ROI
- **Vehicle access**: existing fleet of spray equipment vs move to smaller equipment

Spacing definitions/variations

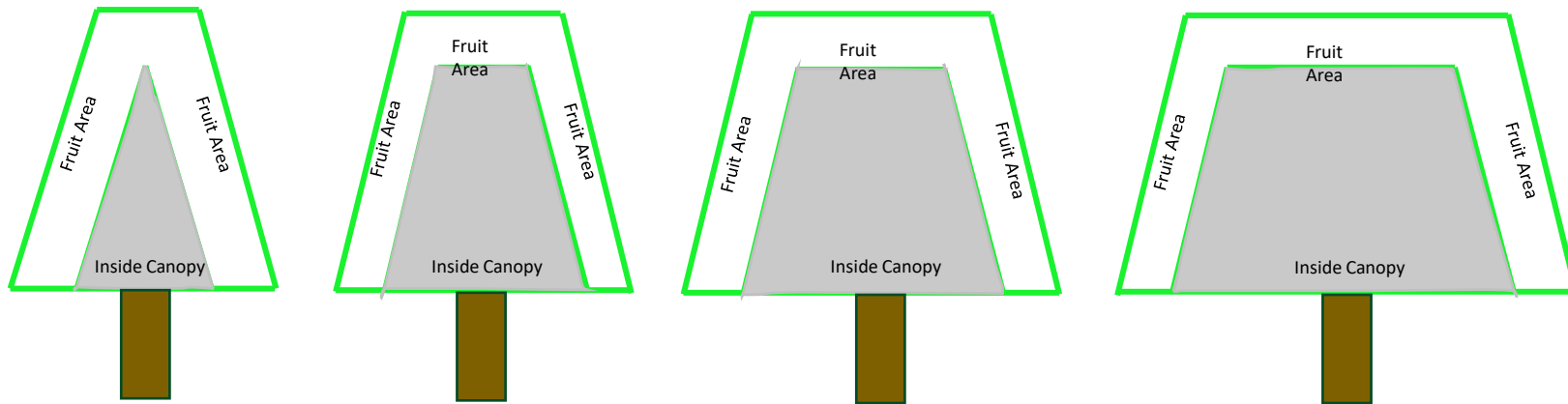
- **High density:** 4 X 1.5 - 5 X 2 m (trees/ha) [**1000 to 1666 trees/ha**]
- **Intermediate:** 5.5 - 6 X 2.5 - 3m [**555 to 730 trees/ha**]
- **Conventional,** wider spacings: 6.5 X 4 - 7 X 5m [**285 to 385 trees/ha**]
- **Tramlines**
- **Trellising:** re-inventing the wheel? Lately some trellis plantings in CA; also in Australia
- **Grove architecture:** pyramidal vs spreading

Tall, wide trees: 7 X 5m



Productive bearing volume

Productive volume increases per ha with denser spacing: less shaded area
Bearing surface: outer periphery



Density of plants/ha	500	400	350	300
Effective production volume (Kg/m ³)	7.27	6.08	5.06	5.33

Tramline



Tramline



Trellis: Tatura/ Y system



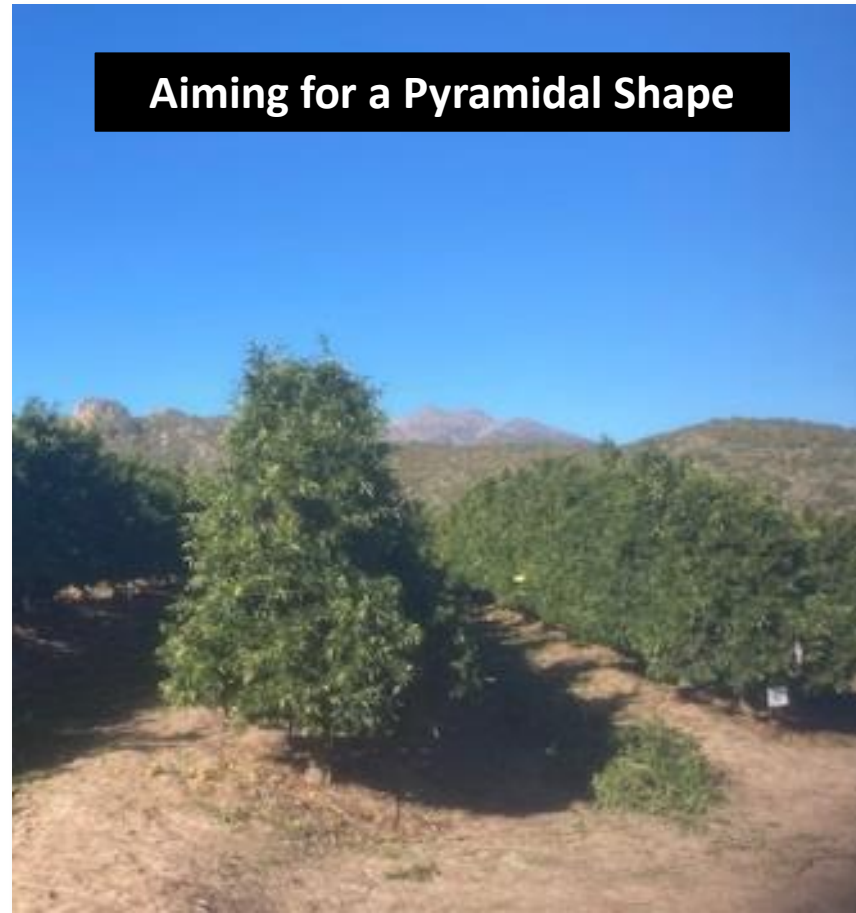
Vertical trellis system



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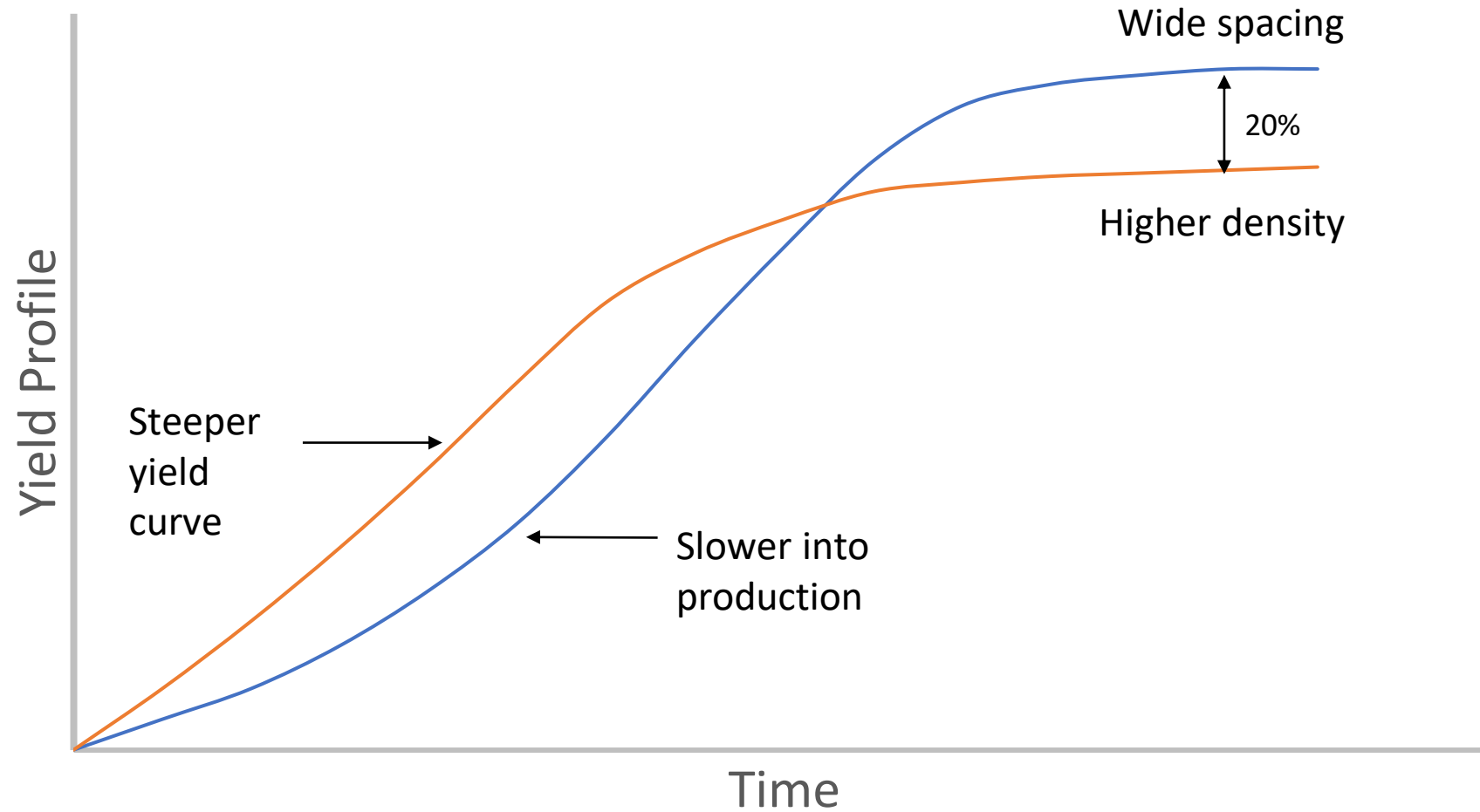
Concepts

- **Deciduous fruit “rule”**: tree height should not exceed **80%** of between-row spacing to not shade out the tree skirts. 5m between, 4m max height
- **Citrus**: the 80% rule never applicable in citrus in my experience; closer to a **60%** rule, i.e., 5m spacing, no more than 3m height to not shade out the skirts; 6m = 3.5m height

Concepts

- **Light interception vs light distribution**
 - Higher density: more light-intercepting leaves (yield) in early years
 - # of trunks in the row not important; hedge-row obtained earlier (more expensive in tree costs)
- Eventually light distribution becomes limiting if correct tree management is neglected (normally the case!)
- **Alternate tree removal:** usually figures into the plan but inevitably done too late (data)

Spacing considerations: LI vs LD



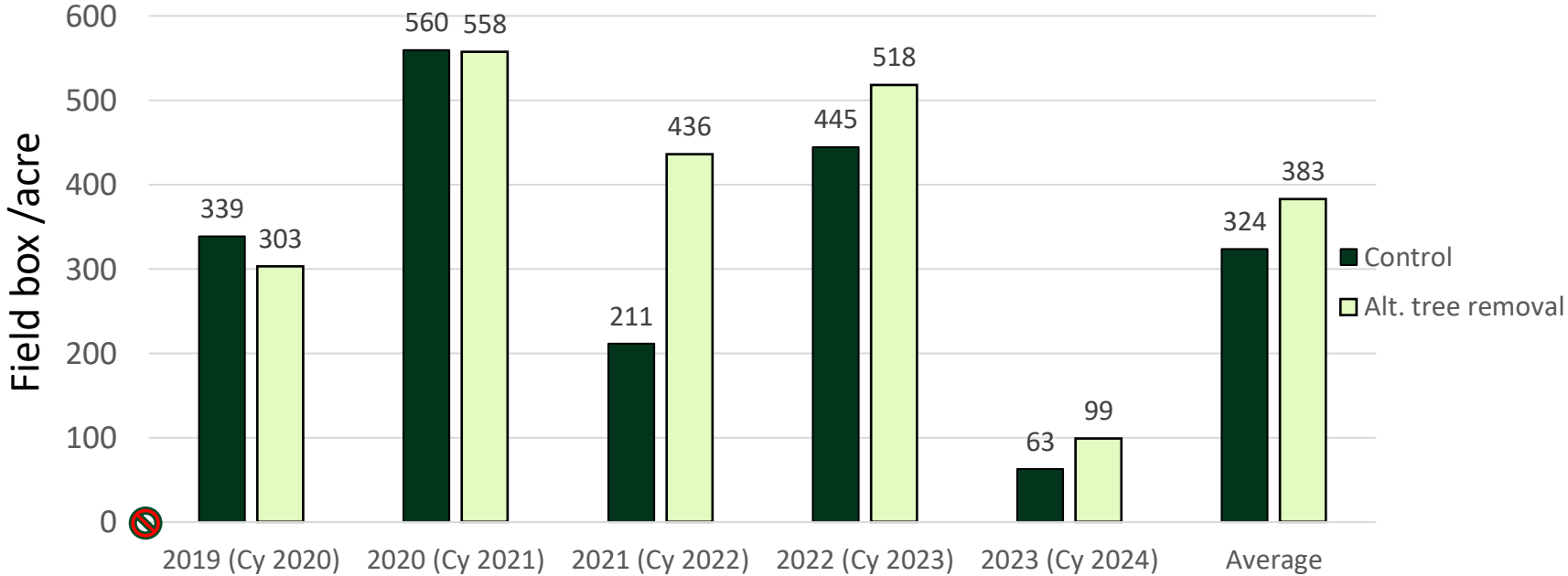
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Alternate tree removal: Yield trend 2019-23

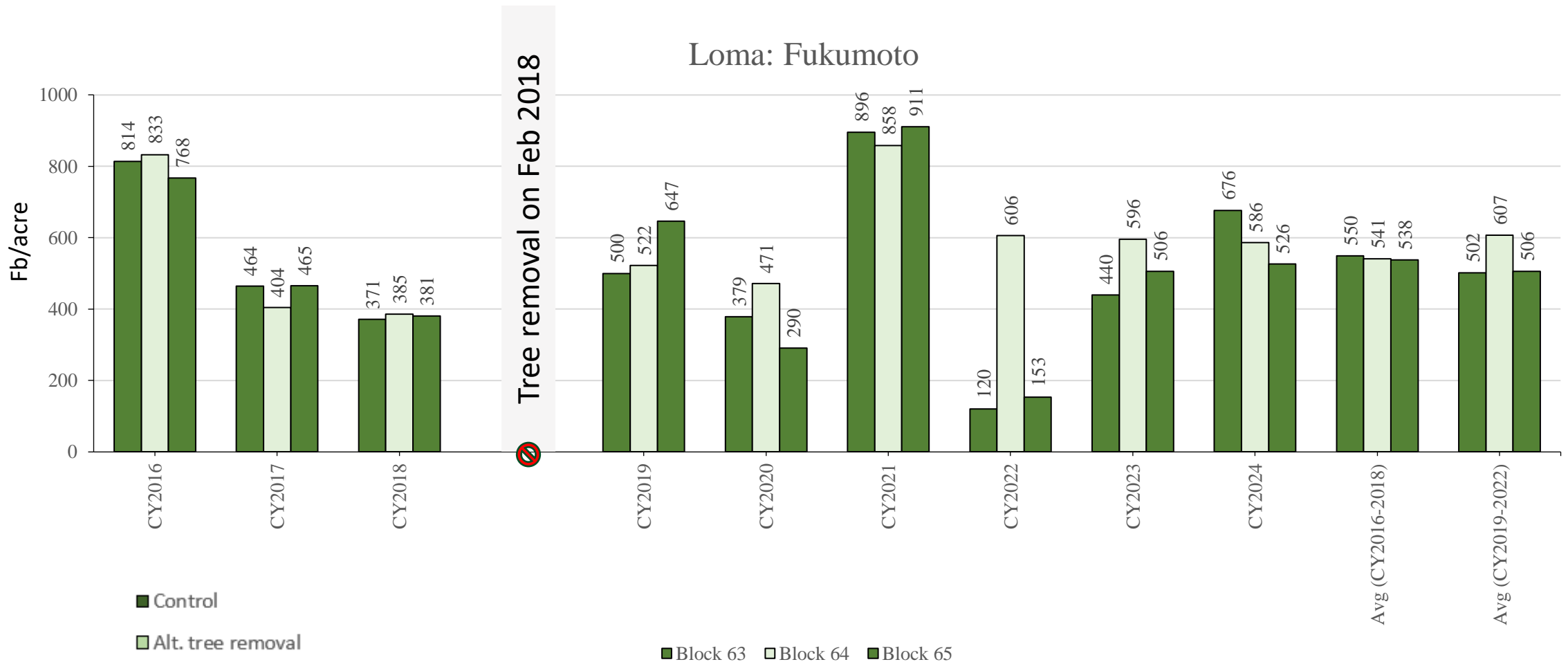
Clementines: ~20%

Alt tree removal: 03/09/2019
 2019 harvest date: 11/4/19 to 11/12/19
 2020 harvest date: 11/11/20 to 11/27/20
 2021 harvest date: 11/30/21 to 12/02/21
 2022 harvest date: 11/12/22 to 11/18/22
 2023 harvest date: 11/14/23 to 11/15/23



Half of the block: alternate tree was removed
Individual treatments were harvested, and bin counts were made

Alternate tree removal: Navel Orange: ~20%



Preparing for the future

- Mechanical pruning
- Harvesting
- Platforms
- Robotic

Mechanical pruning



Equipment: Platforms for Pruning and Picking Mechanization

Primary Challenge Addressed: Labor costs.

What is it? Usage of mobile platforms eliminates ladder work and sets a continuous work pace, thereby increase work rate by introducing productivity tools. There is also a safety benefit.

Stage of Implementation: Six units piloted for harvest and pruning in groves where the spacing allows it.

Usage

■	■	■
CA	TX	MX



Bin Collection



The same unit can be used for both purposes. Unit costs = \$72,000

Equipment: Robotic Harvesting Trials

Primary Challenge Addressed: Current harvesting labor costs and risk of future labor constraints

What is it? Different companies have prototypes of robotic harvesting.

Stage of Implementation: No units are ready for in-field trials, but we continue to engage on development.



Robot grabs the fruit



Clipping mechanism

Robotic harvesting is already in place on apples, but that requires plucking/pulling, unlike the clipping required on citrus.

Variety Growth Habit: Suitability to Higher Density

Variety	Suitability
Satsuma	***
Clementine	**
Leanri	**
RHM/Murcott types	***
Nadorcott-types	***
Navels	*
Valencias	*
Lemons	**
* Not Very Suitable	
** Intermediate	
*** Highly Suitable	

Rootstock considerations for high density

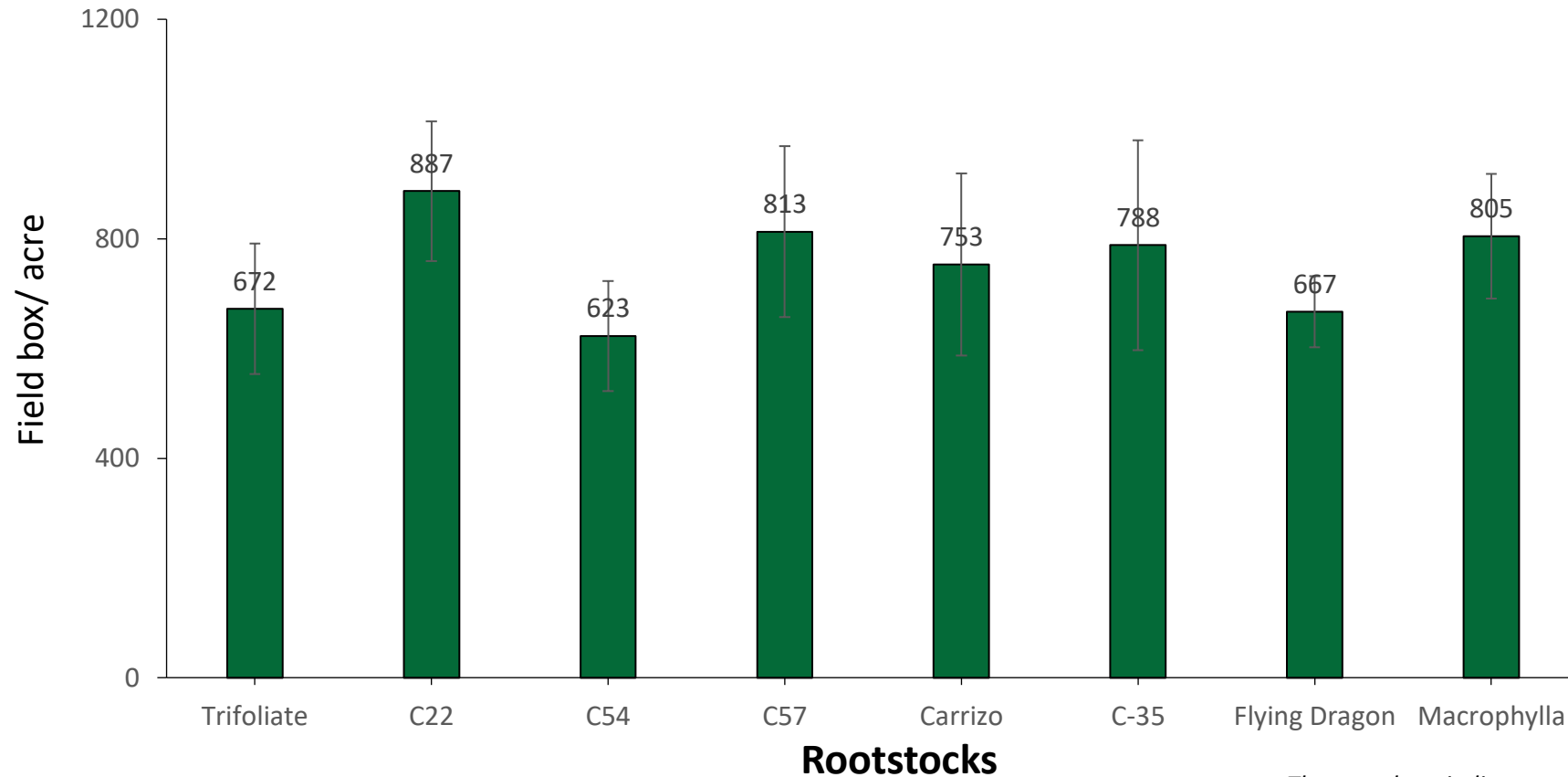
- **Dwarfing rootstocks antithetical** to high density ROI
- Dwarfing rootstocks: growth too slow to fill hectare with productive leaves
- Need to have **reasonably vigorous rootstock** to grow a canopy ASAP
- Otherwise, yield profile too low.
- In California:
 - Trifoliolate -- YES
 - C-35 – YES
 - X639 -- YES
 - Carrizo - NO

High density Tango: Impact of rootstock

Spacing: 5 × 12 [726 trees/acre; 1790 trees /ha]

Plant date: 2011

Yield: Average (2016 - 2020)



The error bars indicate ± standard error of mean

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In summary...

Why should you space closer?

Early yields: light interception --- as many productive leaves as possible in initial years

Smaller trees: ease of pruning/picking; mechanization

ROI

Why not?

Light distribution: eventually distribution of light becomes limiting if tree canopy not managed

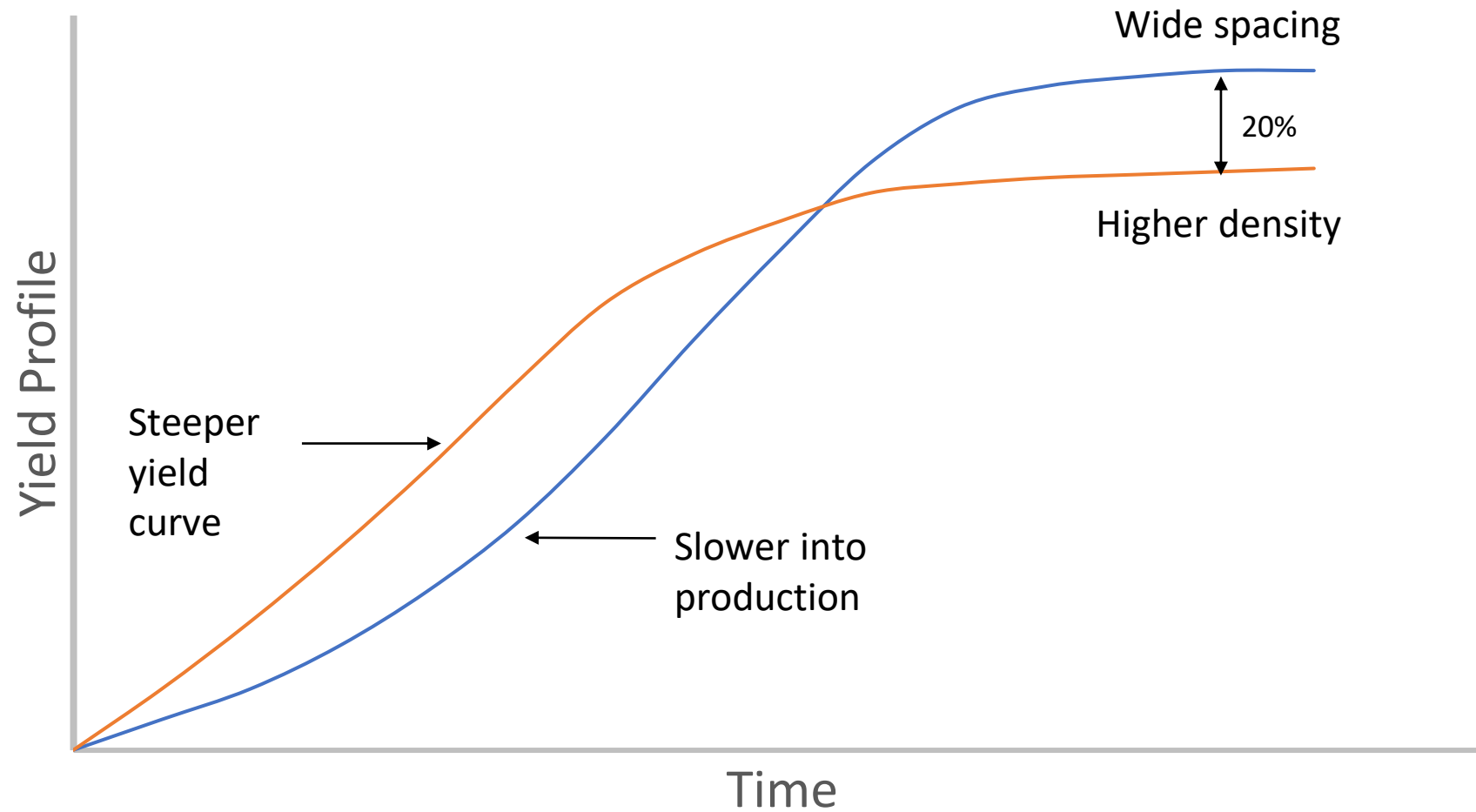
Take home message

- There is no “right” spacing
- It depends on the **philosophy** of the grower: intensive or extensive
- Future considerations may dictate a certain tree architecture [**mechanization**]
- **Variety** specific
- **Climate** specific
- **Country-specific** – at least it will be going forward
- If I **buy** an orchard, likely a conventional spacing; if I **plant** an orchard, likely much higher density

Take home message

- My spacing (Mediterranean-type climes): 5 X 2 for most; 6 X 3 for certain vigorous combinations
- **Higher density spacings quite often fail to achieve the intended goals unless sticking to a predetermined plan: once optimal light interception is achieved, prune early and correct to maintain the desired light distribution maintain productivity**

Spacing consideration



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