Opportunities for Improved Profitability Now and in the Future

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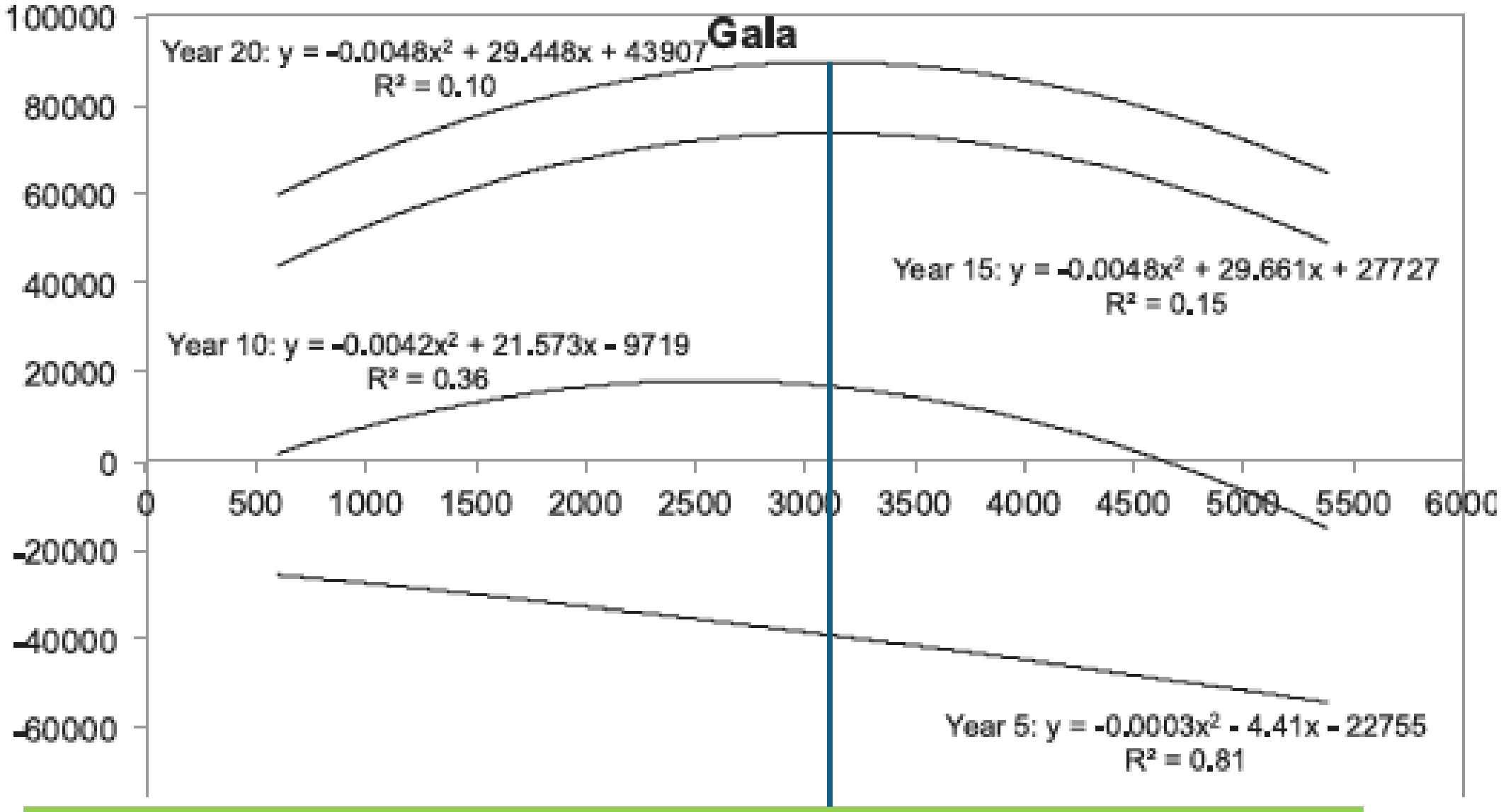
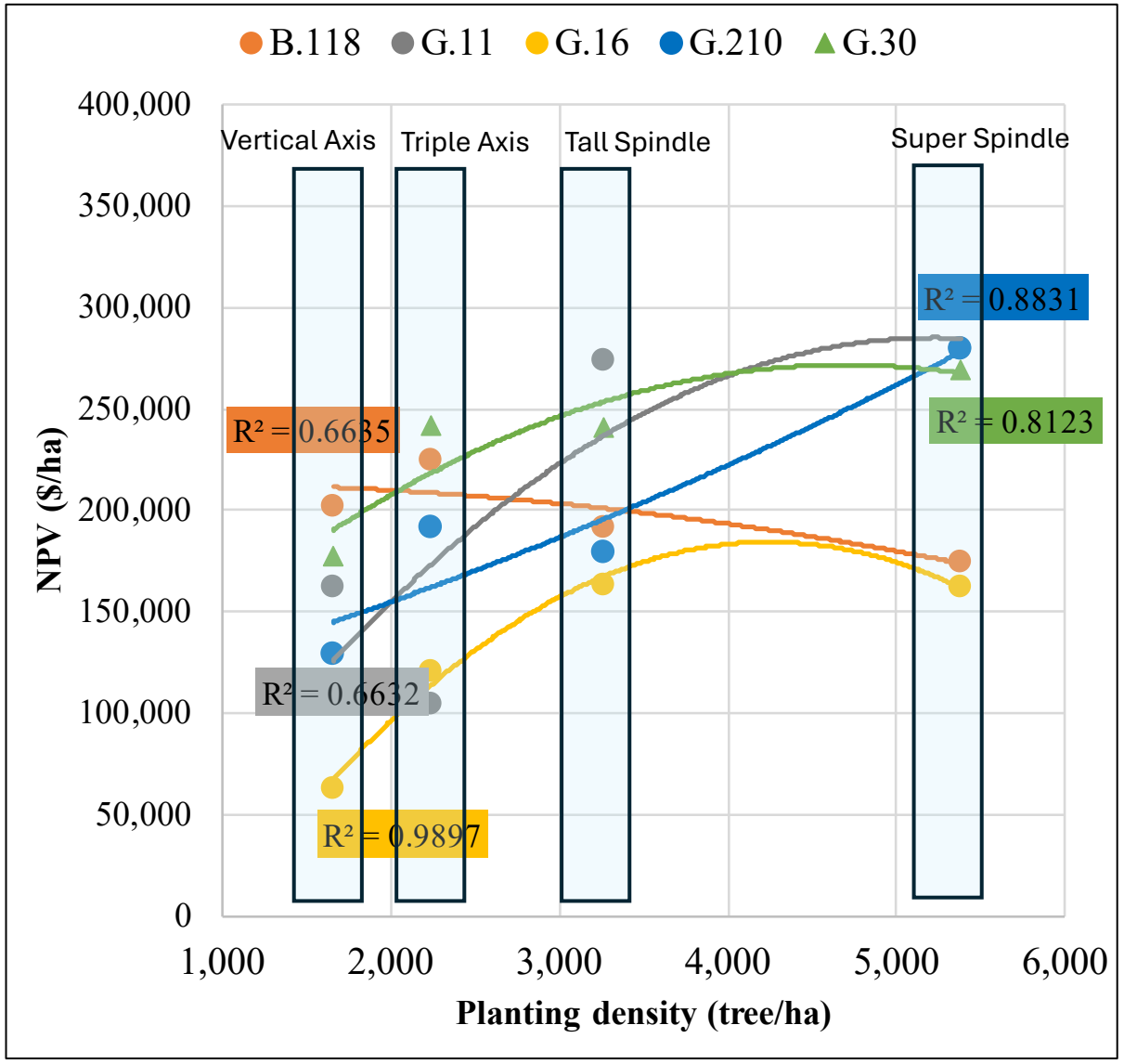
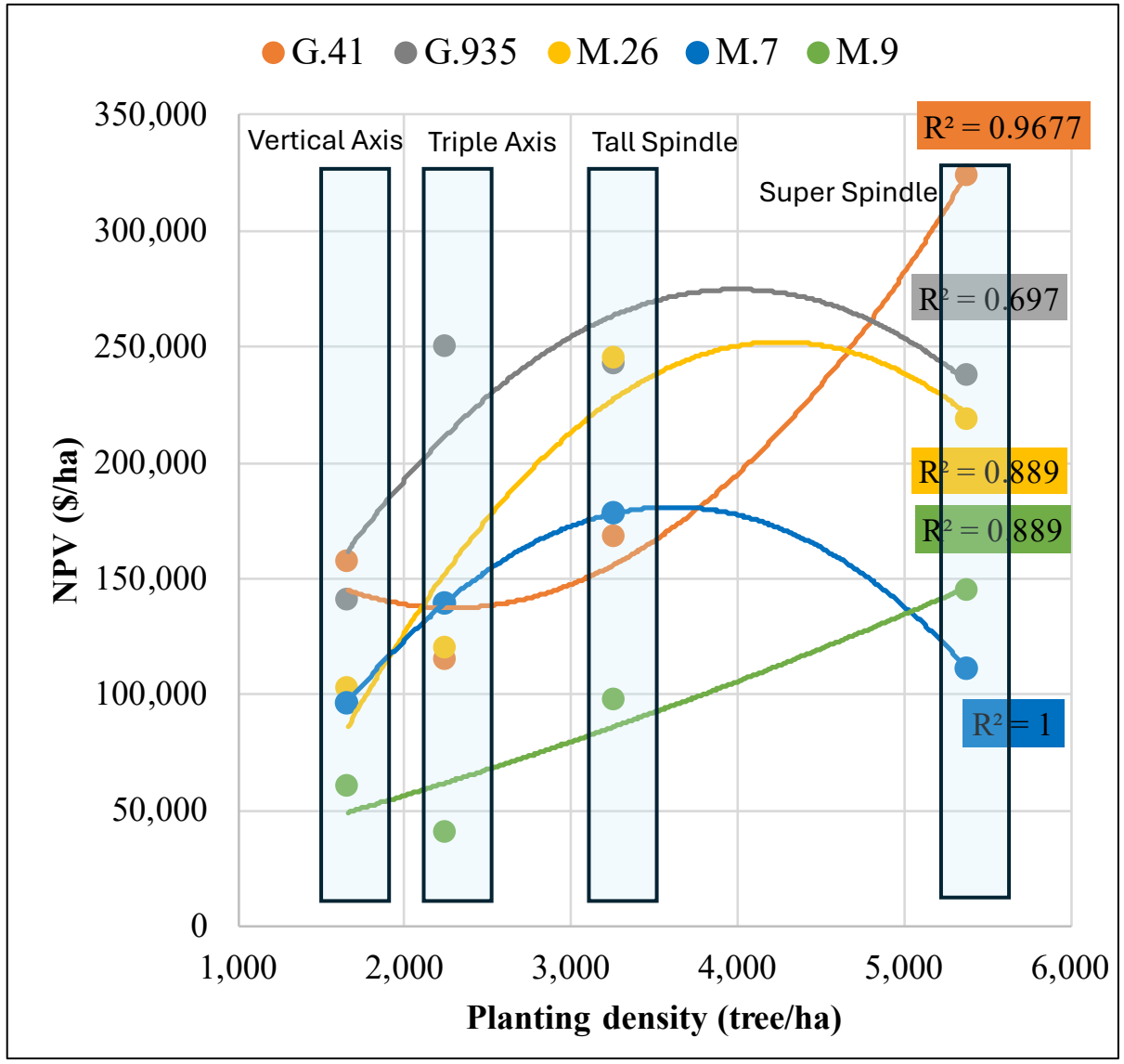
Effect of Planting Density on 20-Year Profitability of Gala Apple Trees – Geneva NY



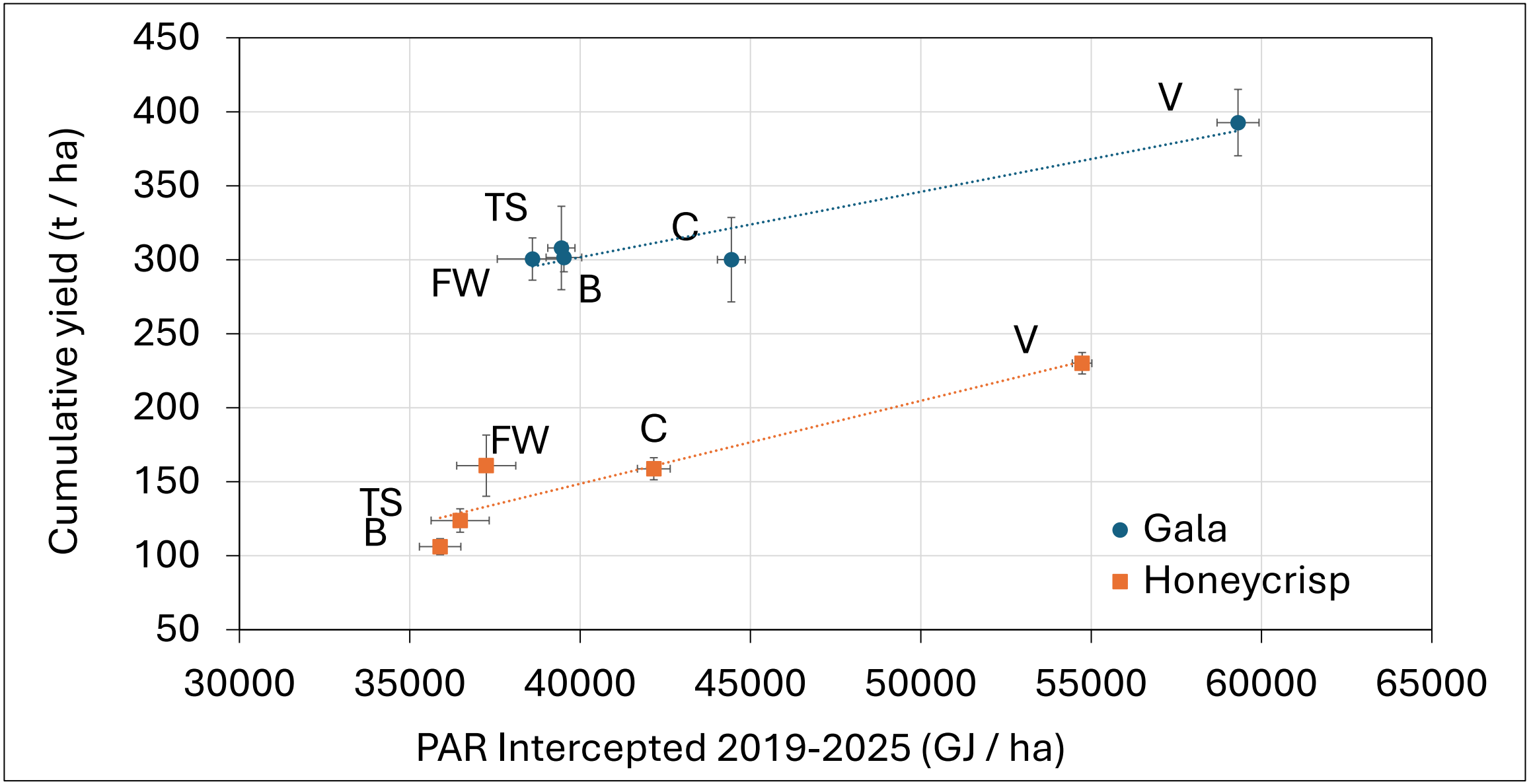
Optimum planting density was 3,072 trees/ha = 1243 trees/acre=2.9’ X 12’ or 3’ X 11’
Higher or lower planting densities were not as profitable

Profitability of Super Chief Delicious after 20 years on 10 rootstocks and 4 systems

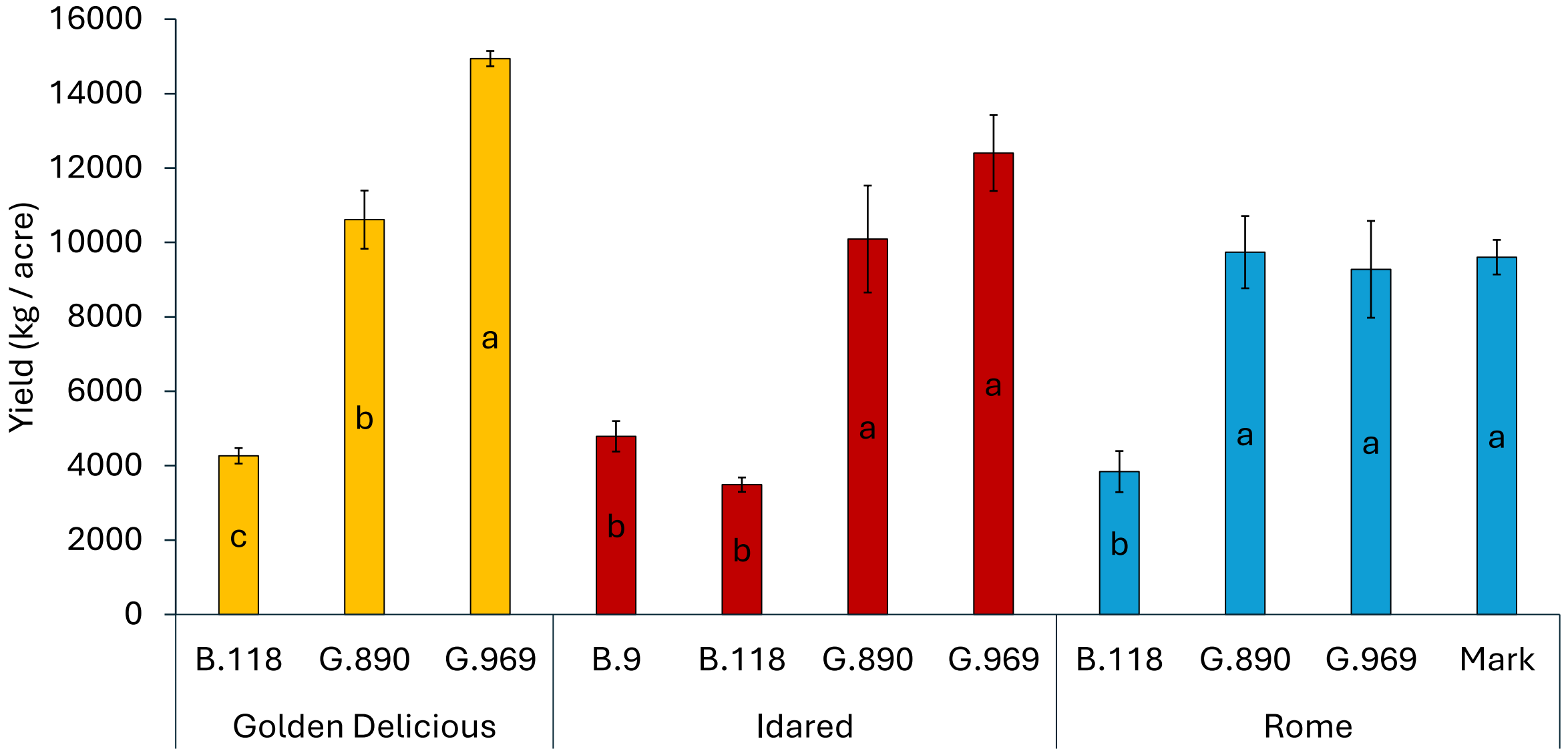




9-Year Cumulative Yield of 5 Robot Ready High Density Orchard Systems



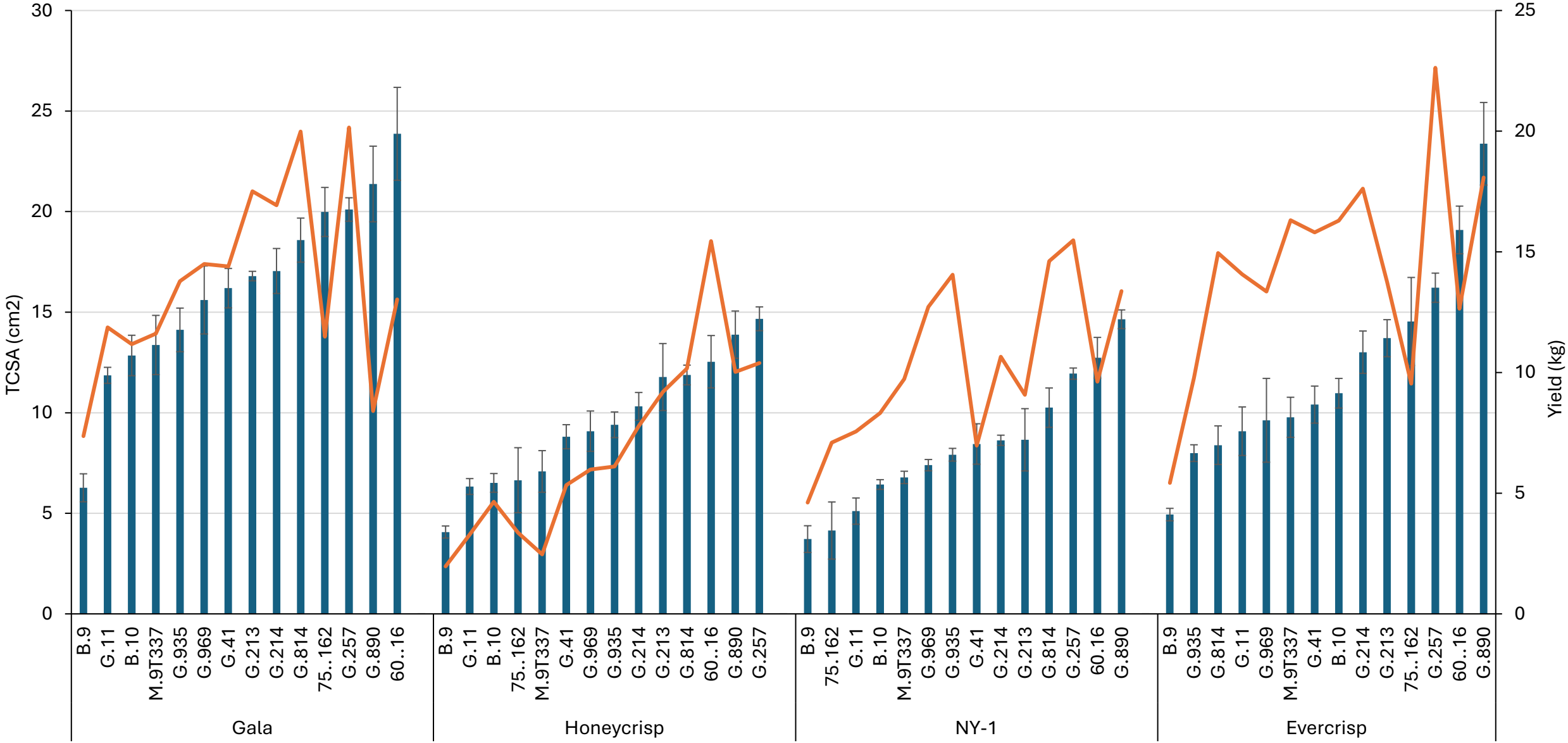
Modernizing Processing Orchards –Third Year Yield - Breslawski



Conclusions about Planting Density and Systems

- The optimum planting density for most varieties is about 1200 trees/acre. (3’ X 11’)
- For spur type Delicious the optimum planting density is higher ~1600 trees/acre. (2.5’ X 11’)
- For growers who grow their own trees the optimum planting density is ~1600 trees/acre. (2.5’ X 11’)
- For processing orchards, the optimum planting density is likely ~900 trees/acre (4’ X 12’) with a medium vigor rootstock like G.969.
- V-systems produce higher yield but have more complicated trellises.
- The planar cordon system from New Zealand does not appear to offer a significant advantage over the Tall Spindle.
- Bi-axis or multi-axis trees do no offer a significant advantage over single stem trees.

Statewide Rootstock Demonstration Plots-(Geneva)



Choose the right rootstock

- Honeycrisp=G.969 or G.214 (high yields with low bitter pit)
- Snapdragon=G.257, or G.969 (sufficient vigor to fill 3’ planting spacing and large fruit size)
- Gala=G.11 or G.41 (high yields and large fruit size)
- Evercrisp =G.214, G.969, G.41 or G.11 (High yields but need more evaluation of effect of rootstock on storage internal browning
- Processing orchards= G.969, G.257 or G.890 (Can plant in high density and produce high yields from year 3 onward)

Precision Crop Load Management: achieving optimal fruit number by tree

Pruning

- **<u>Bud Counting with digital cameras</u>**
- Guiding human workers with bud load maps
- Robotic pruners

Blossom Thinning

- Blossom counts with digital cameras
- Pollen Tube Growth Model
- **<u>Variable rate sprays</u>**

Fruitlet Thinning

- Fruitlet counts with digital cameras
- Carbon Balance Model
- **<u>Variable rate sprays</u>**
- Fruit Growth Rate Model

Hand Thinning

- **<u>Fruit counts with digital cameras</u>**
- Guiding human workers with fruit maps

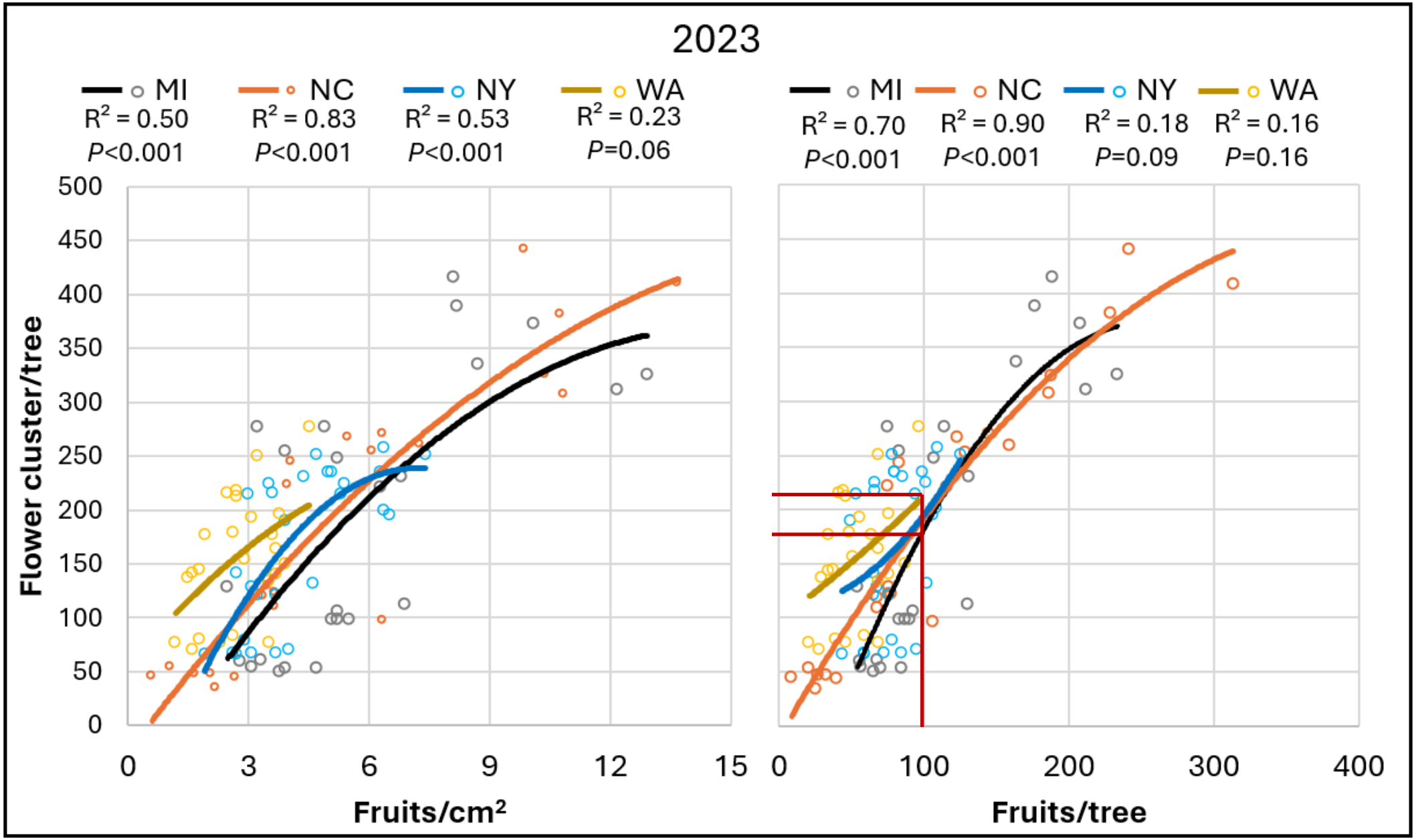
Precision Pruning

Precision pruning is a process of reducing the number of flower buds to a predetermined number through pruning using the rules of Tall Spindle pruning and then spur extinction pruning. (Robinson, et al., 2013).

How many flowering spurs to leave?

	Honeycrisp	Gala
	72ct	100ct
	259g	180g
• 1 bud per final fruit number	92	128
• 1.25 buds per final fruit number	115	160
• 1.5 buds per final fruit number	138	192
• 2 buds per final fruit number	184	256
• 3 buds per final fruit number	276	384
• 4 buds per final fruit number	368	512

Multi-location studies on pruning severity and final fruit number in 2023

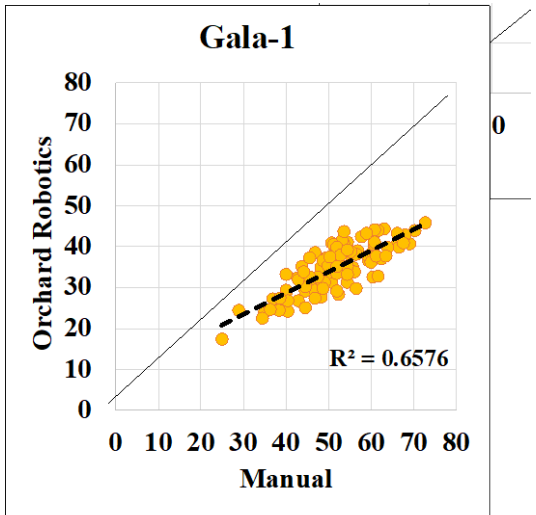


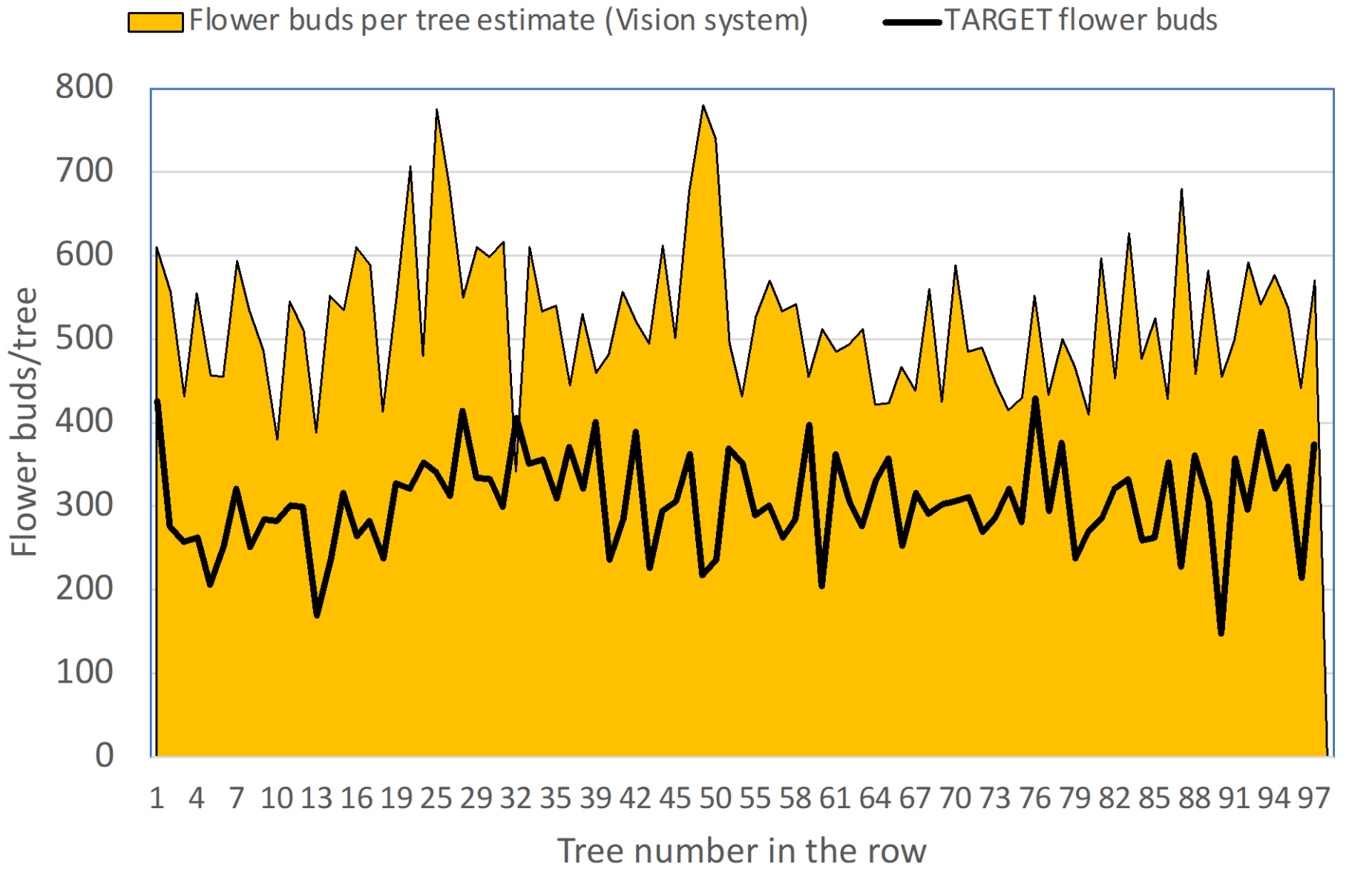
Summary of Studies on Pruning Severity

- Whenever more flowering buds are left on the tree, there will be more apples at harvest.
- Reducing number of flowering buds per tree to a pre-determined target through pruning will help ensure that the optimum number of fruit will be obtained at harvest.
- The optimum number of flower buds per tree varies by year and depends on how weather affects the efficacy of thinning sprays.
- Each grower must decide the level of severity of pruning but leaving more than 200 buds almost always results in too many fruit at harvest and biennial bearing.
- For NY we suggest 1.5X number of flower buds : final fruit number.
- For Tall Spindle keep 25-30 small branches (<3.4”diameter) = about 6 branches between each wire = 5-6 fruits/branch = 125-150 fruits/tree

Can we measure variability in dormant bud number per tree with cameras to guide dormant pruning?

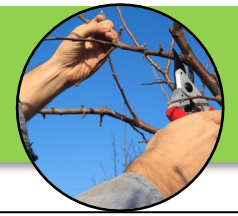
12-year-old Gala/M.9 trees scanned in the dormant season with Orchard Robotics Camera System (A correction factor was applied based on hand counting 10 trees.)

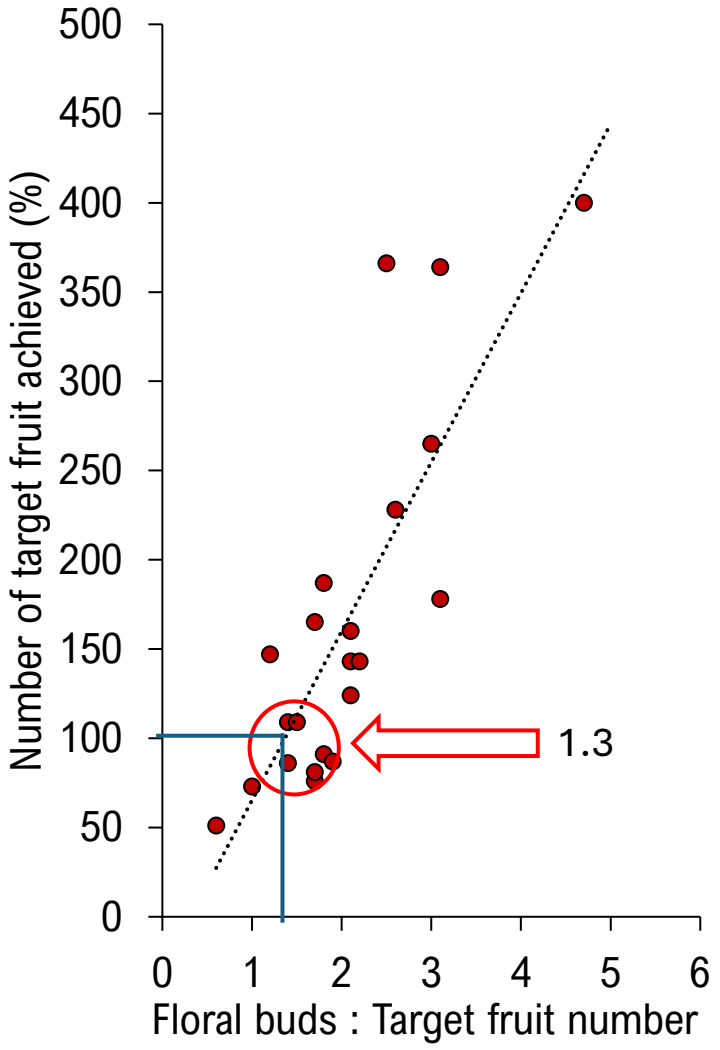


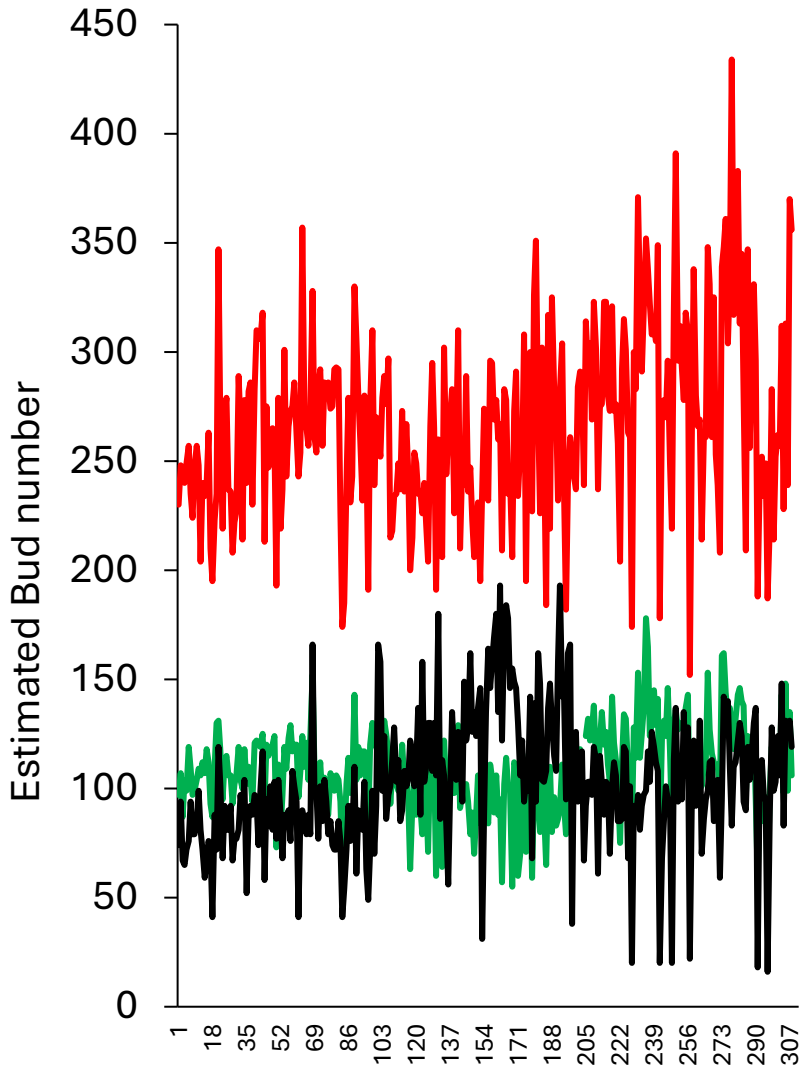


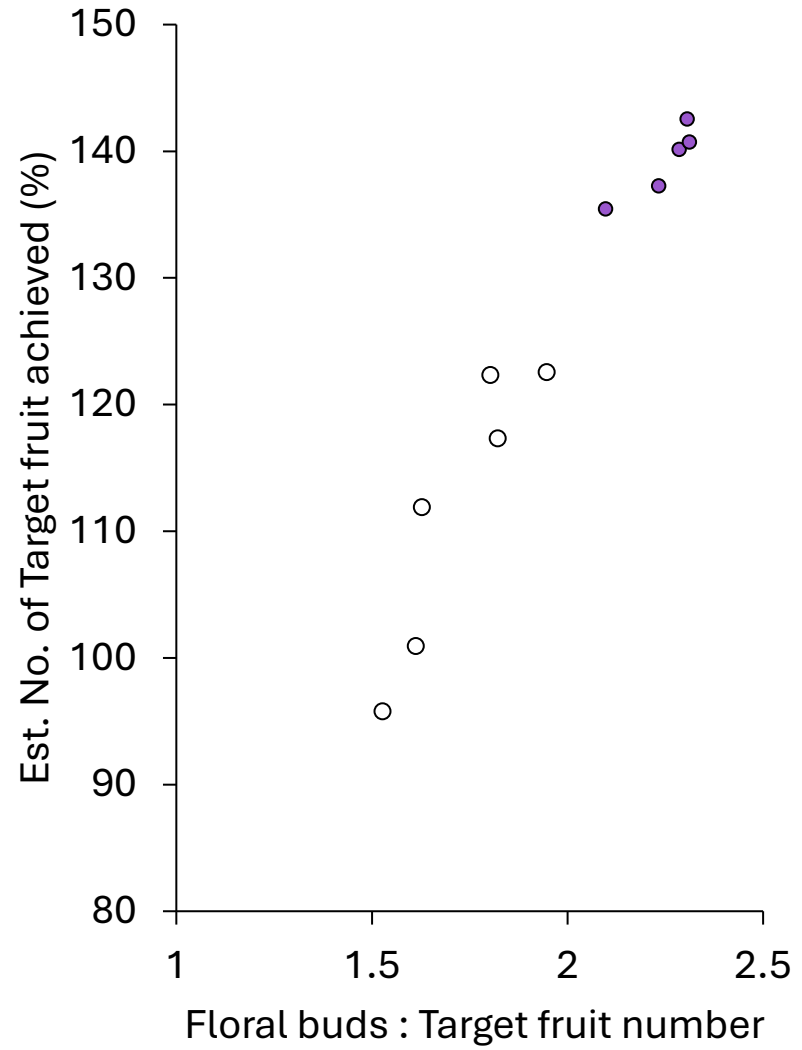
Precision pruning

vivid machines





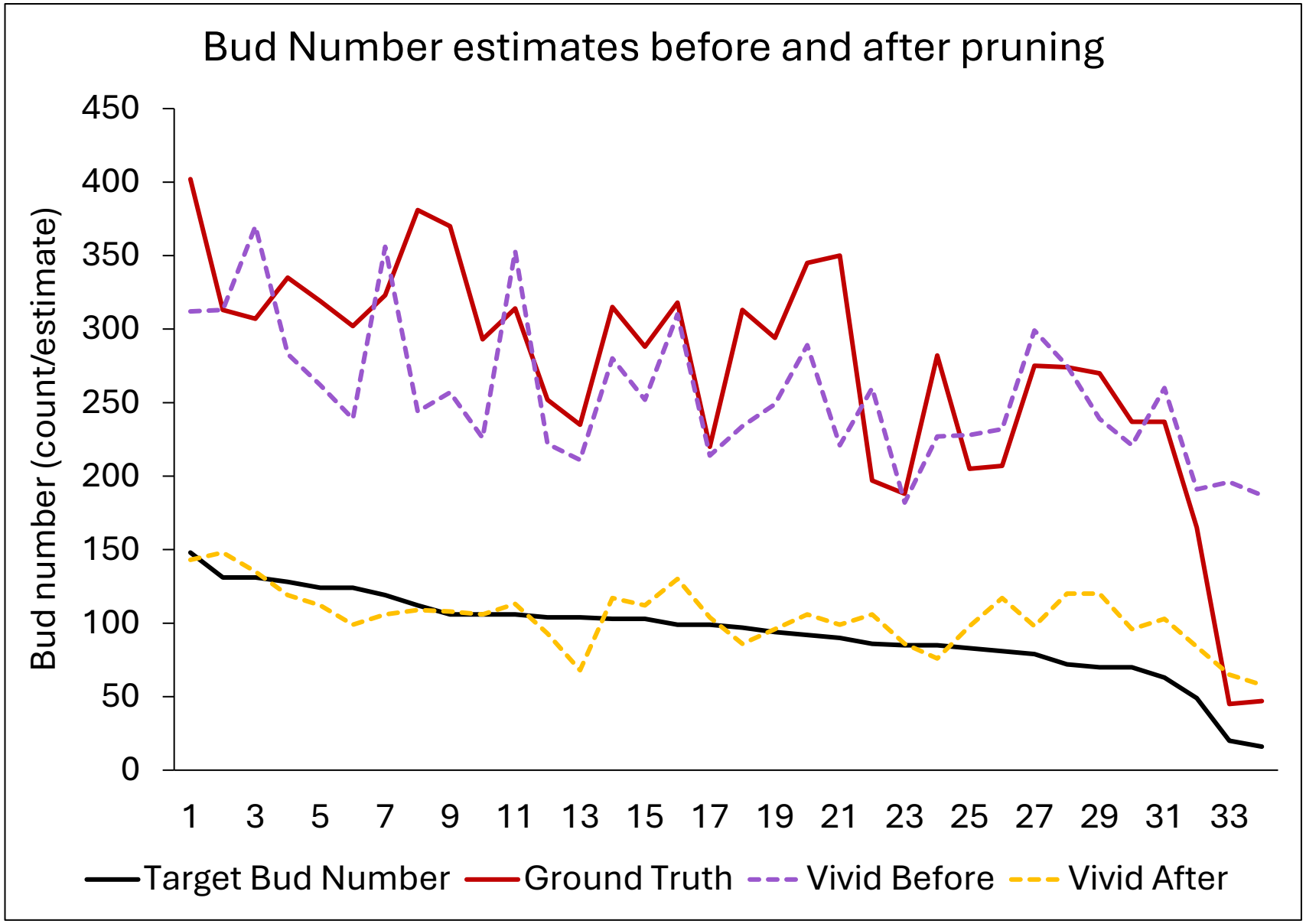


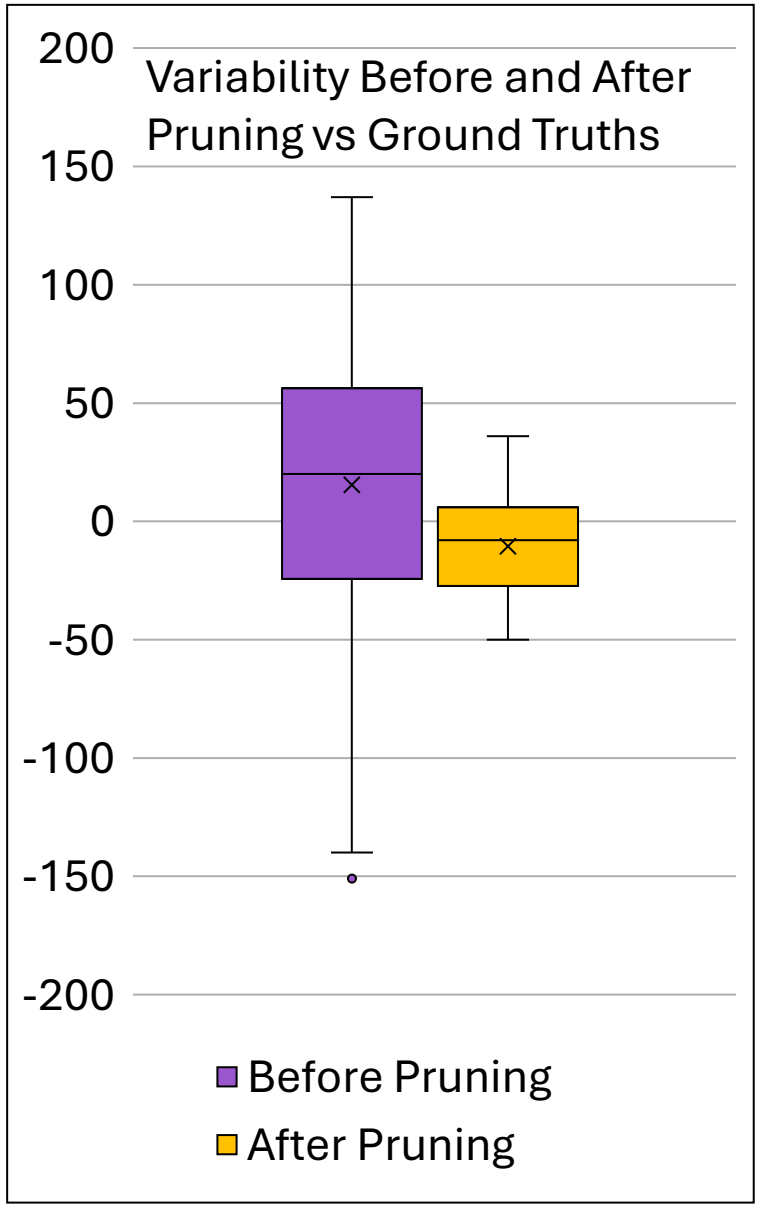


Robinson et al. (2021) Acta Hortic. 1314.18

Precision Pruning to Manage Floral Bud Number

vivid machines.

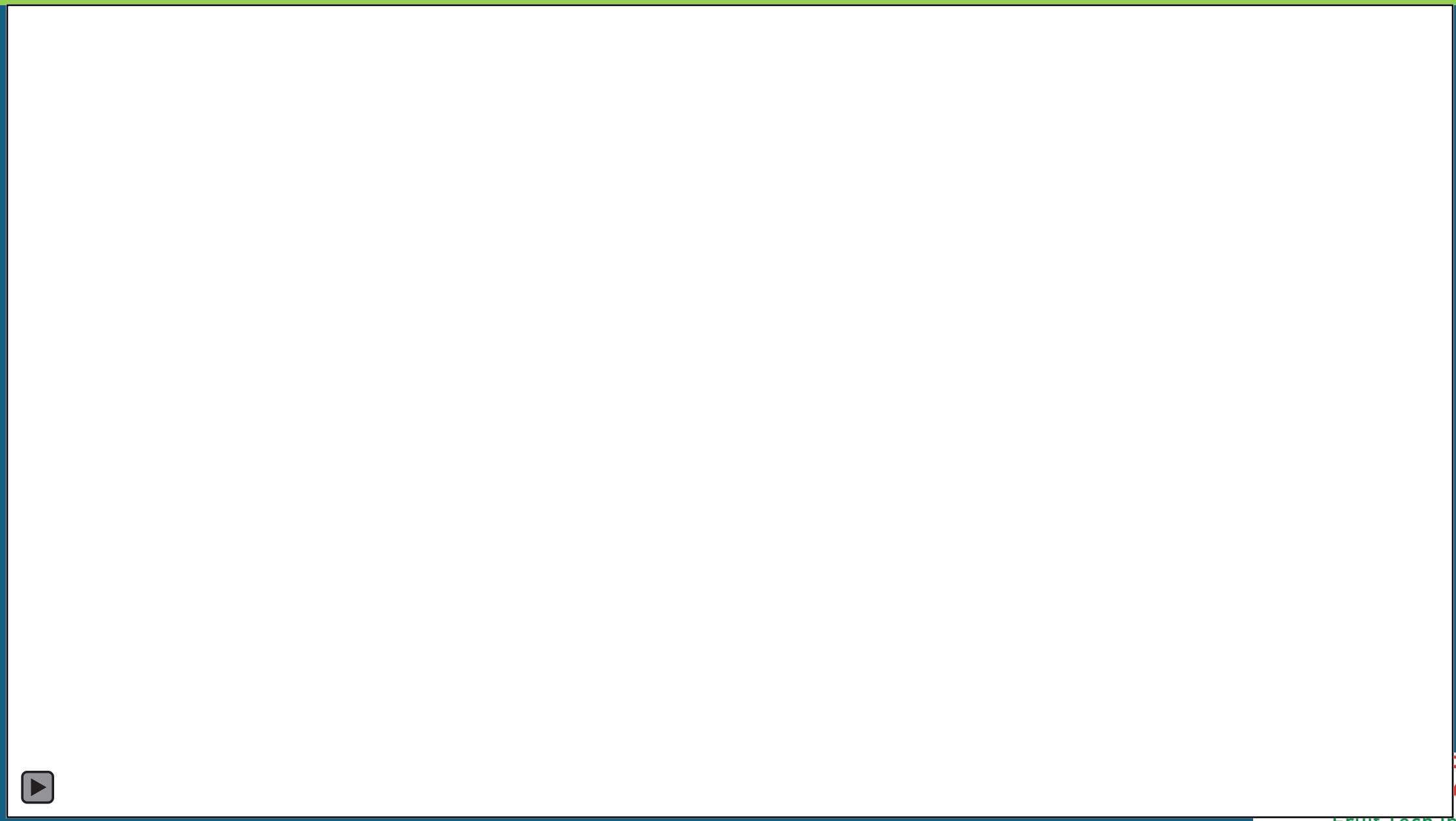




Summary of Digital Bud Counting to Guide Pruning

- Dormant bud digital counting requires a correction factor.
- Dormant bud digital counting must also measure a normalizing factor (TCA, Canopy Vol., Total branch length etc.)
- Digital data on bud number to guide pruning requires individual tree data which is best captured by ground driven cameras. Drones are not useful.
- To utilize maps of dormant bud number per tree before and after pruning requires a method to communicate actionable information to the human worker. We do not yet have such a system

Variable Rate Spraying for Chemical Thinning



Steps to use maps for variable rate spraying

Acquire and Process Images

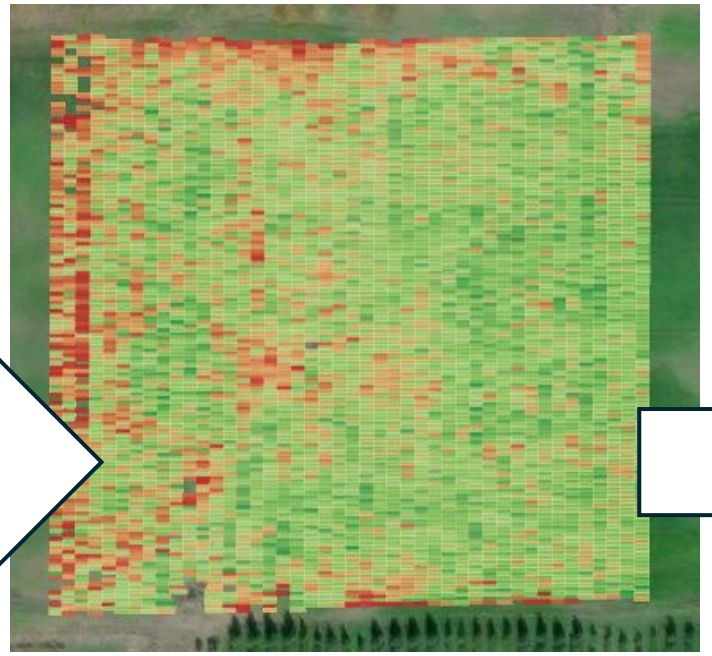
vivid machines

OUTFIELD

Orchard Robotics

Aurea IMAGING

Generate Maps and Tasks



Agromanager

RAVEN

QGIS

Aurea IMAGING

Apply Tasks

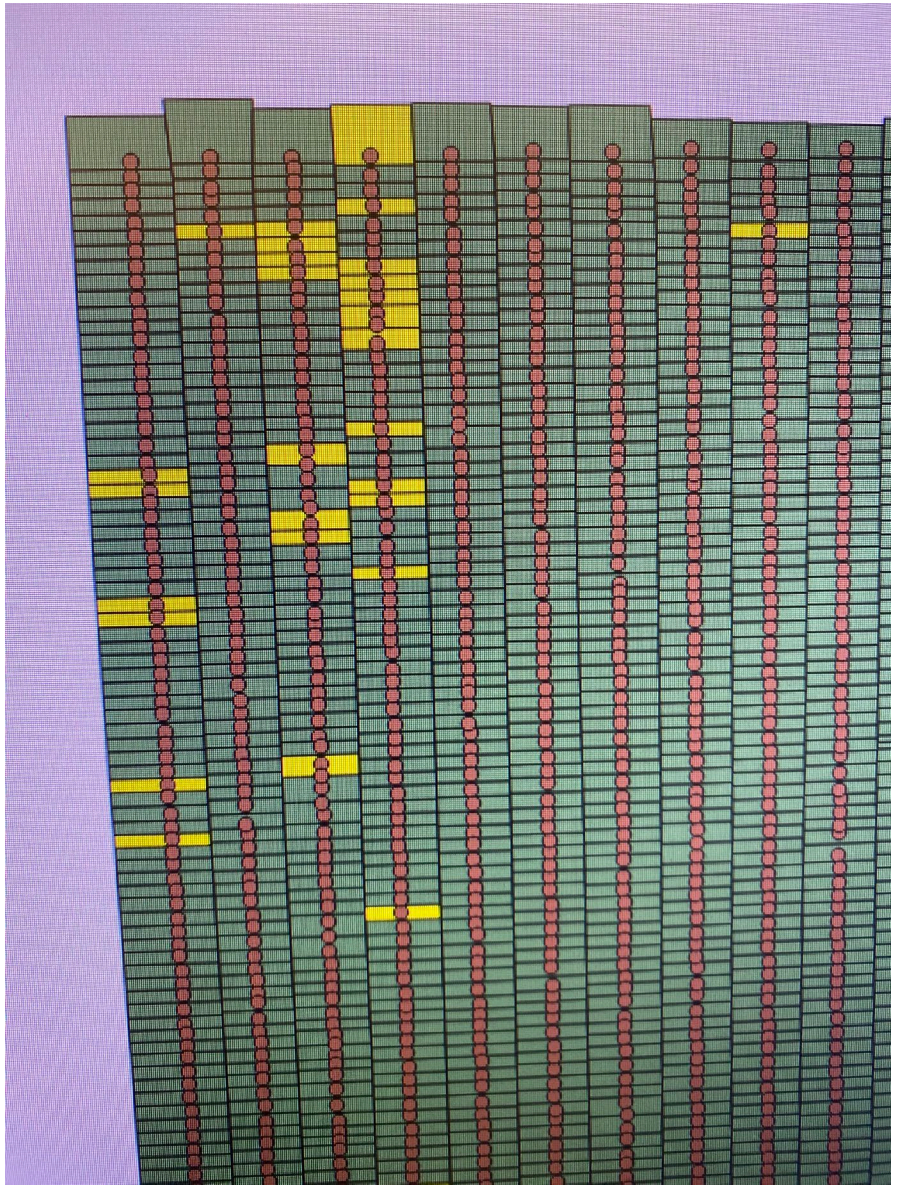
H.S.S.

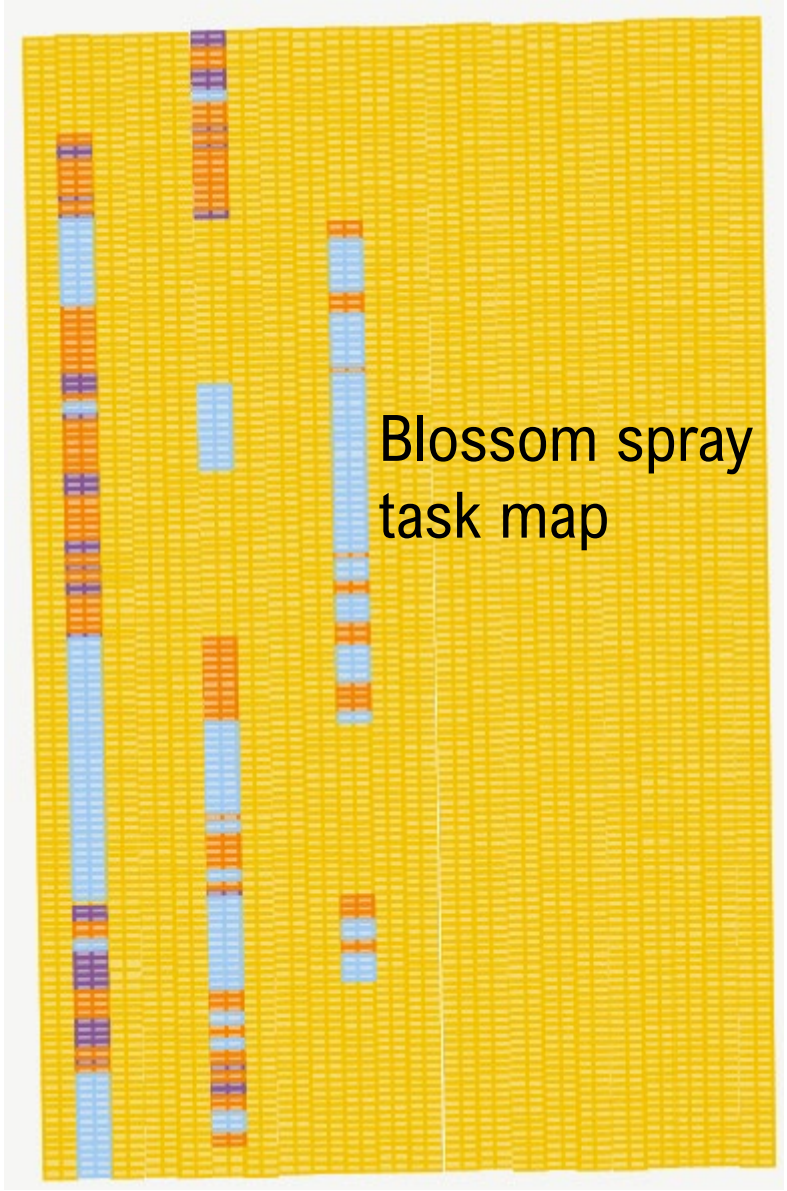
Hol Spraying Systems

MUNCKHOF

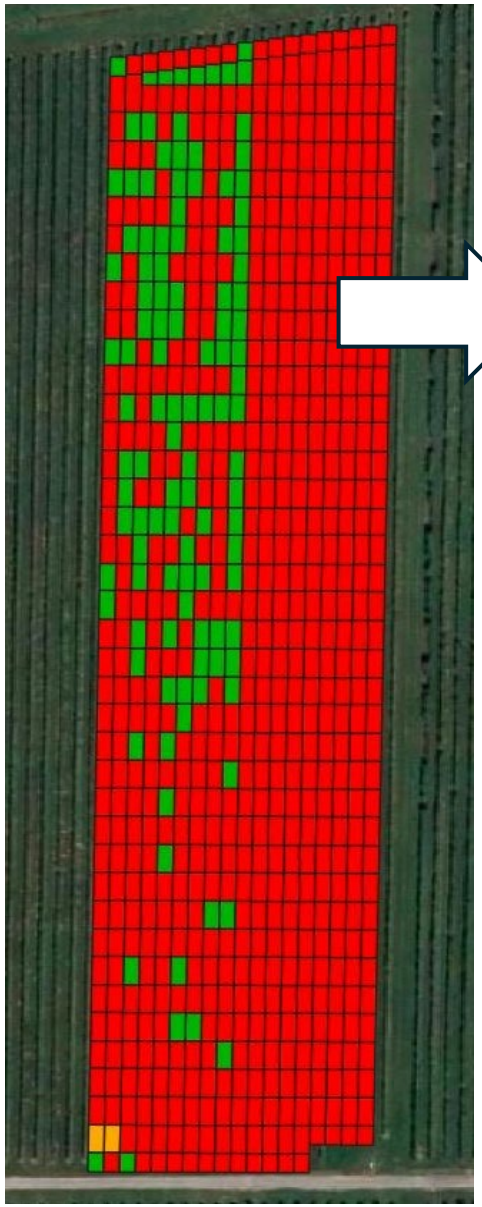
Fruit Tech Innovators

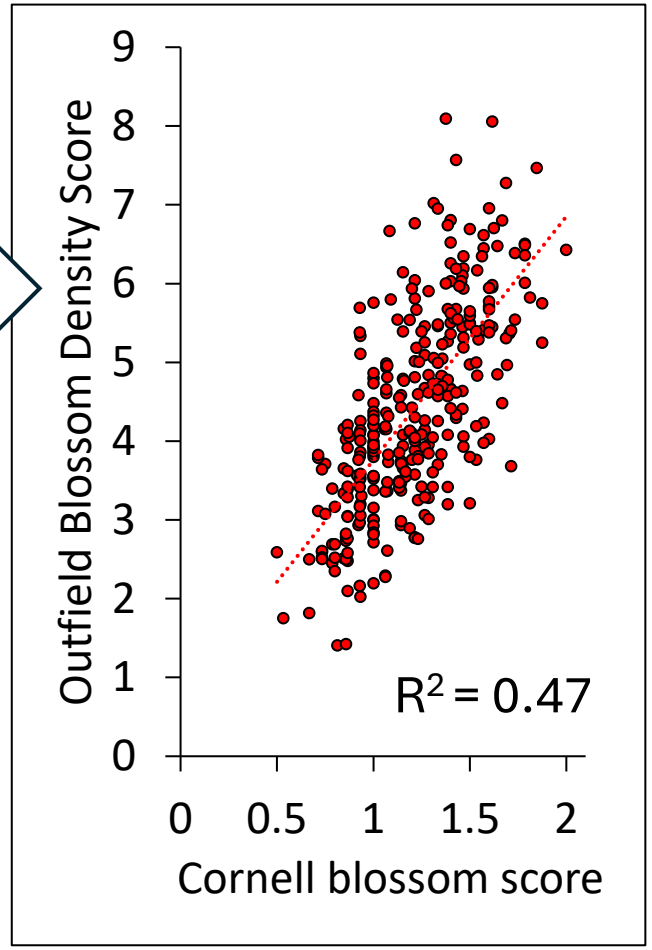
Precision Thinning: Blossom and task maps to guide

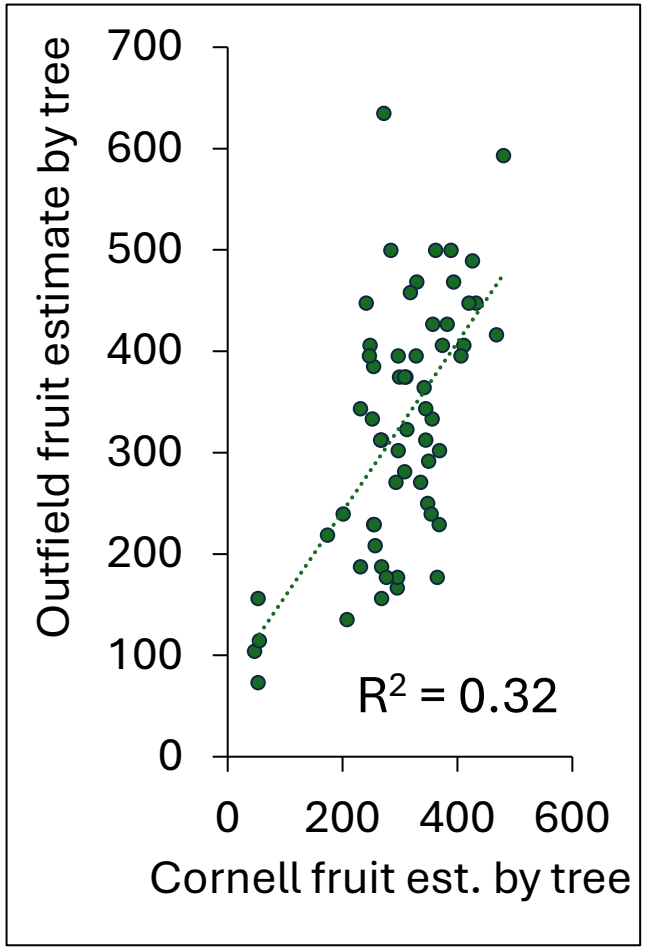


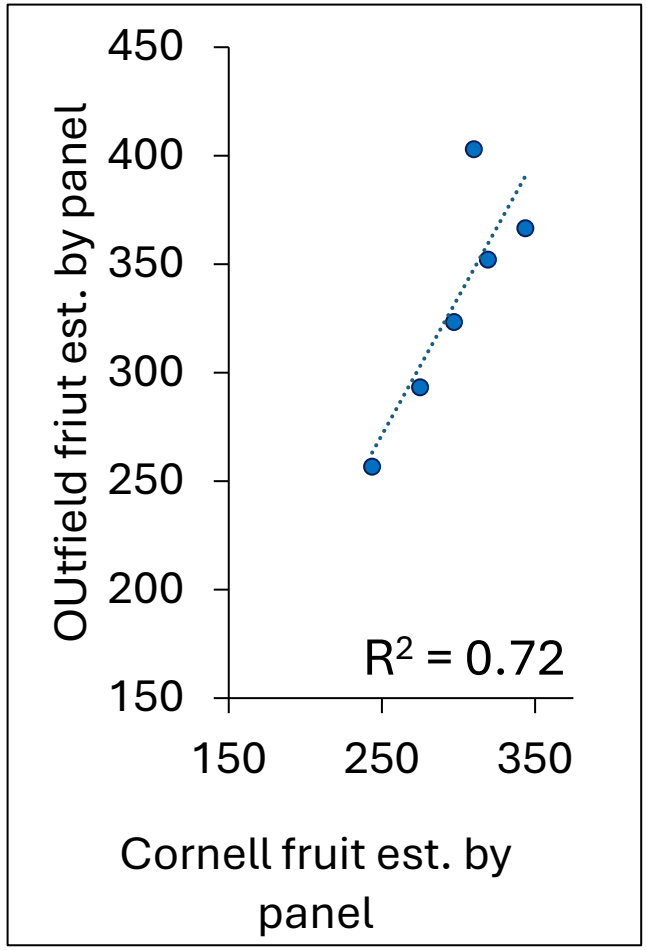


Panel-level drone surveys for blossom density to guide variable rate sprays



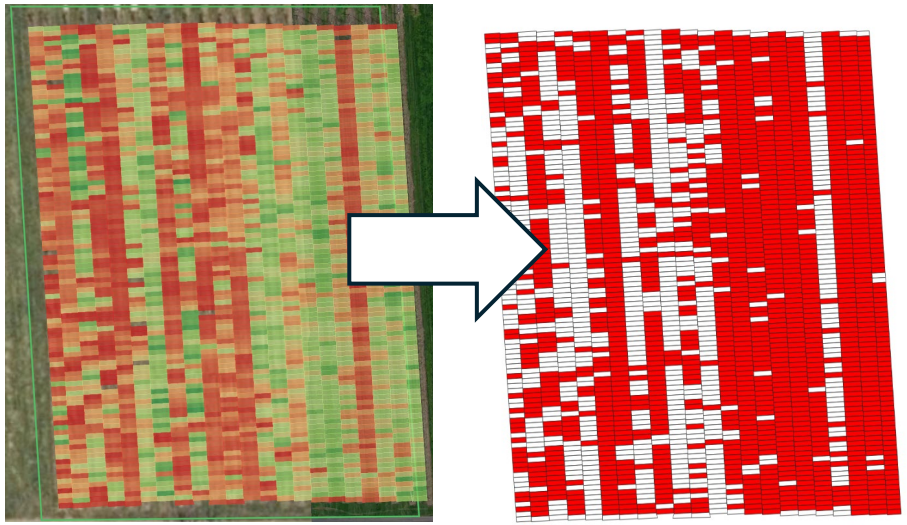


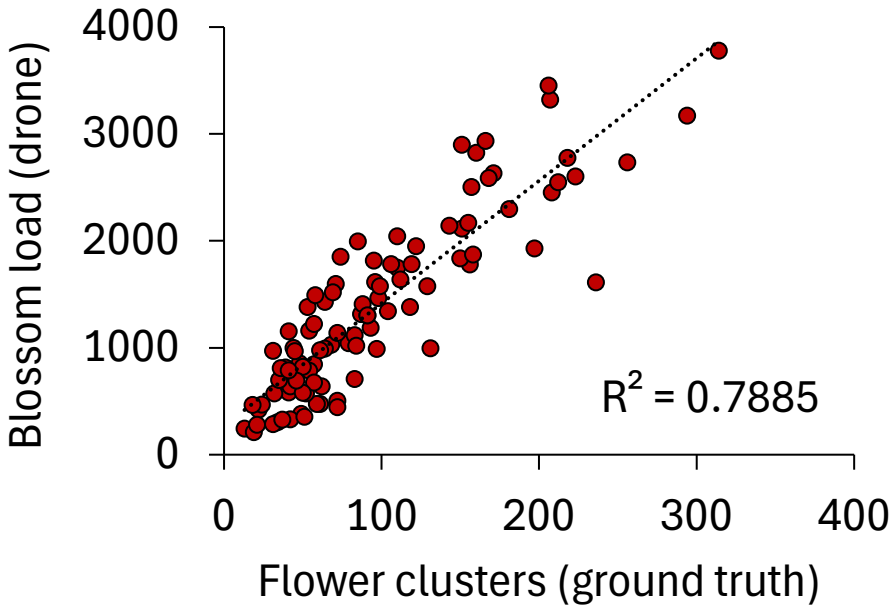




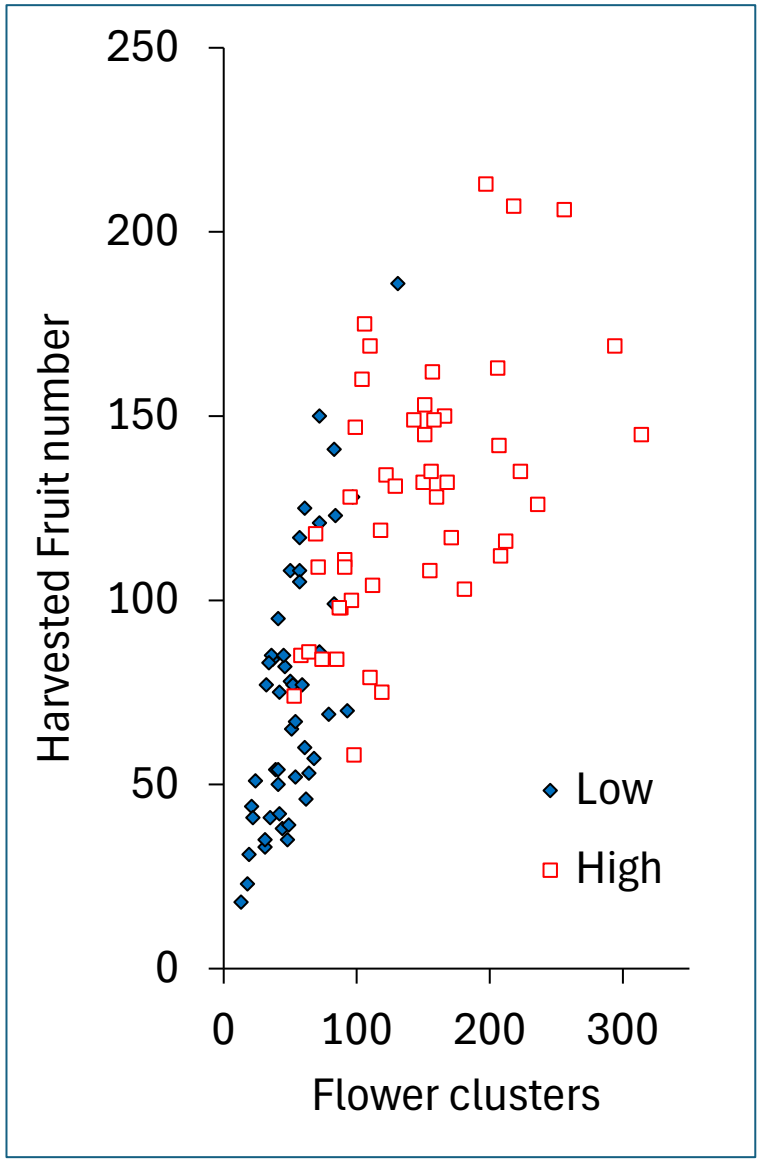
- Panel estimates are accurate, but does not account for tree-by-tree variability in orchard

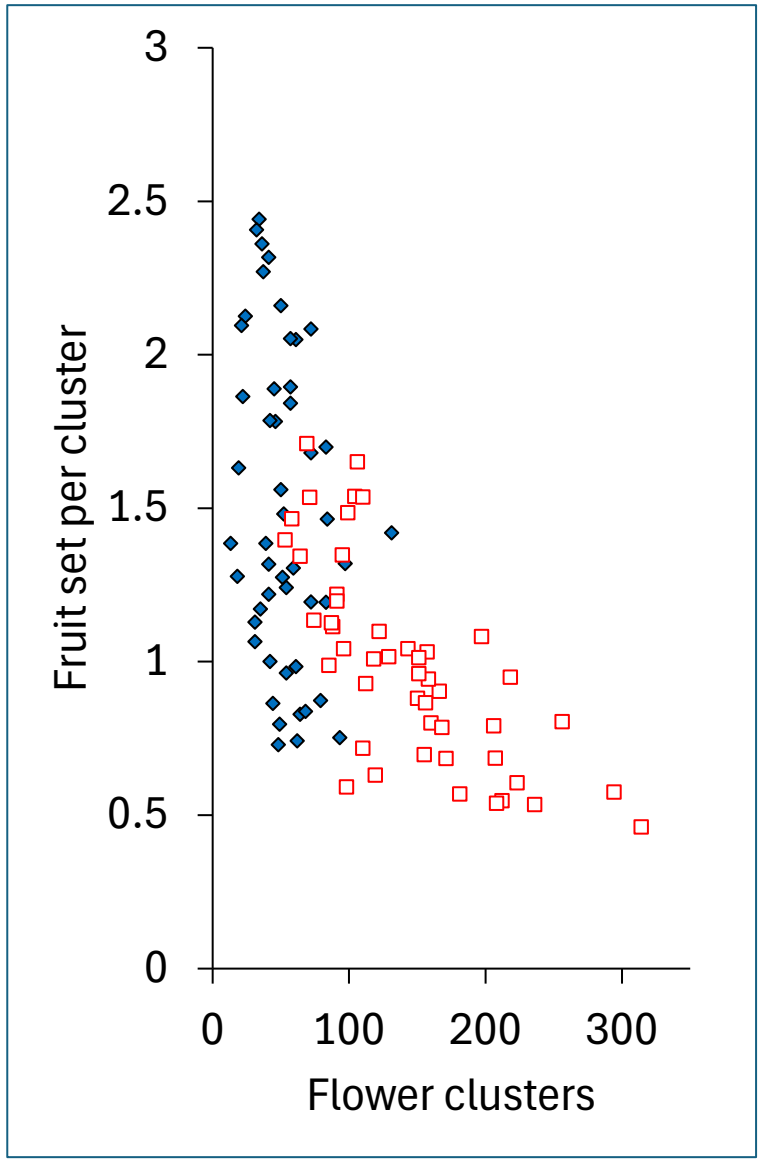
Drone survey of single-tree blossom density to guide variable rate thinning spray

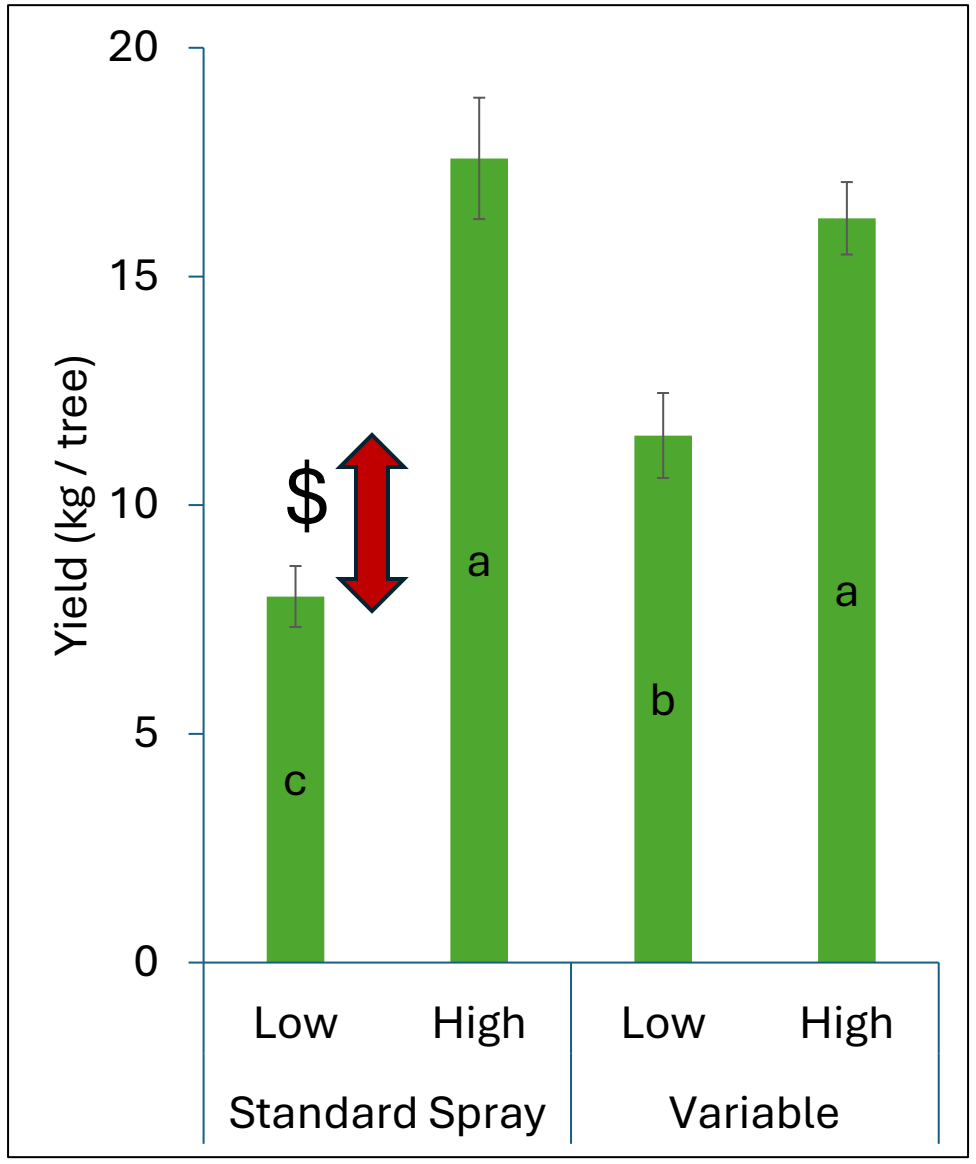




Drone survey of single-tree blossom density to guide variable rate thinning spray







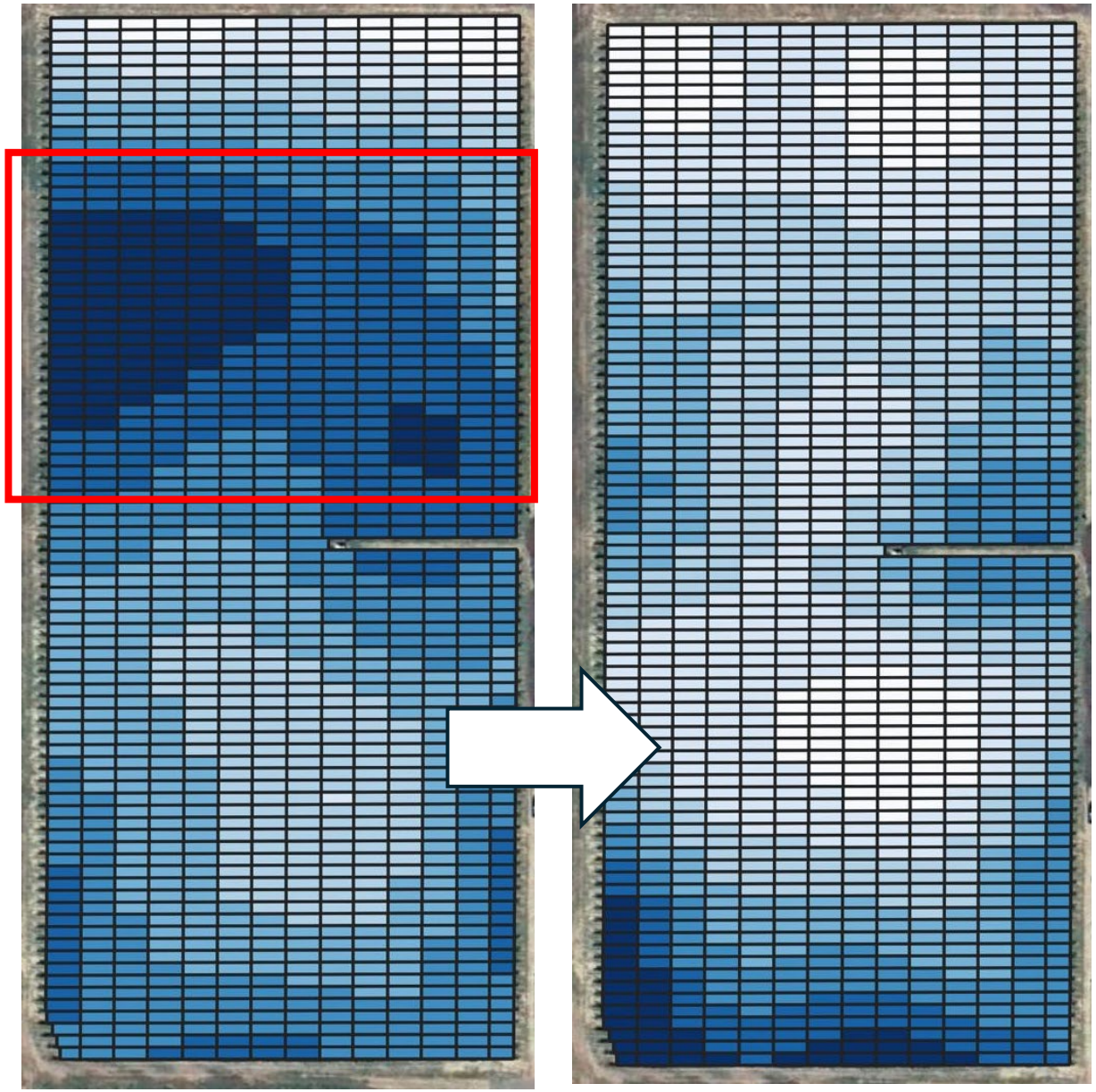
Summary of Variable Rate Chemical Thinning

- Variable Rate Sprays can target individual trees, but the GPS mapping must be very precise.
- Variable Rate Spraying is most useful when blossom density is variable between trees. It is less valuable when blossom density is uniform among trees.
- Example benefit of variable rate spraying
  - If target fruit number = 100
  - 50% of trees have more than target number of blossom clusters. These should be thinned to single fruits = 100 fruits on 50% of the trees
  - However, if the other 50% of trees have less than target number of blossoms. These should be thinned to doubles = 50 cluster X 2 fruits/cluster =100 fruits on 50% of the trees
  - With conventional spraying all trees thinned to singles then total fruit number =75
  - **With 1320 trees/acre the 25 extra fruits/tree=33,000 more fruits/acre=16.5 more bins/acre X $400 per bin = $6,600 per acre**

Can we use cameras to guide hand thinning?

10-year-old Gala/G.41 trees scanned before hand thinning and after hand thinning with Orchard Robotics Camera System (Thinning was done based on the pre-thinning scan of fruit number per tree.)

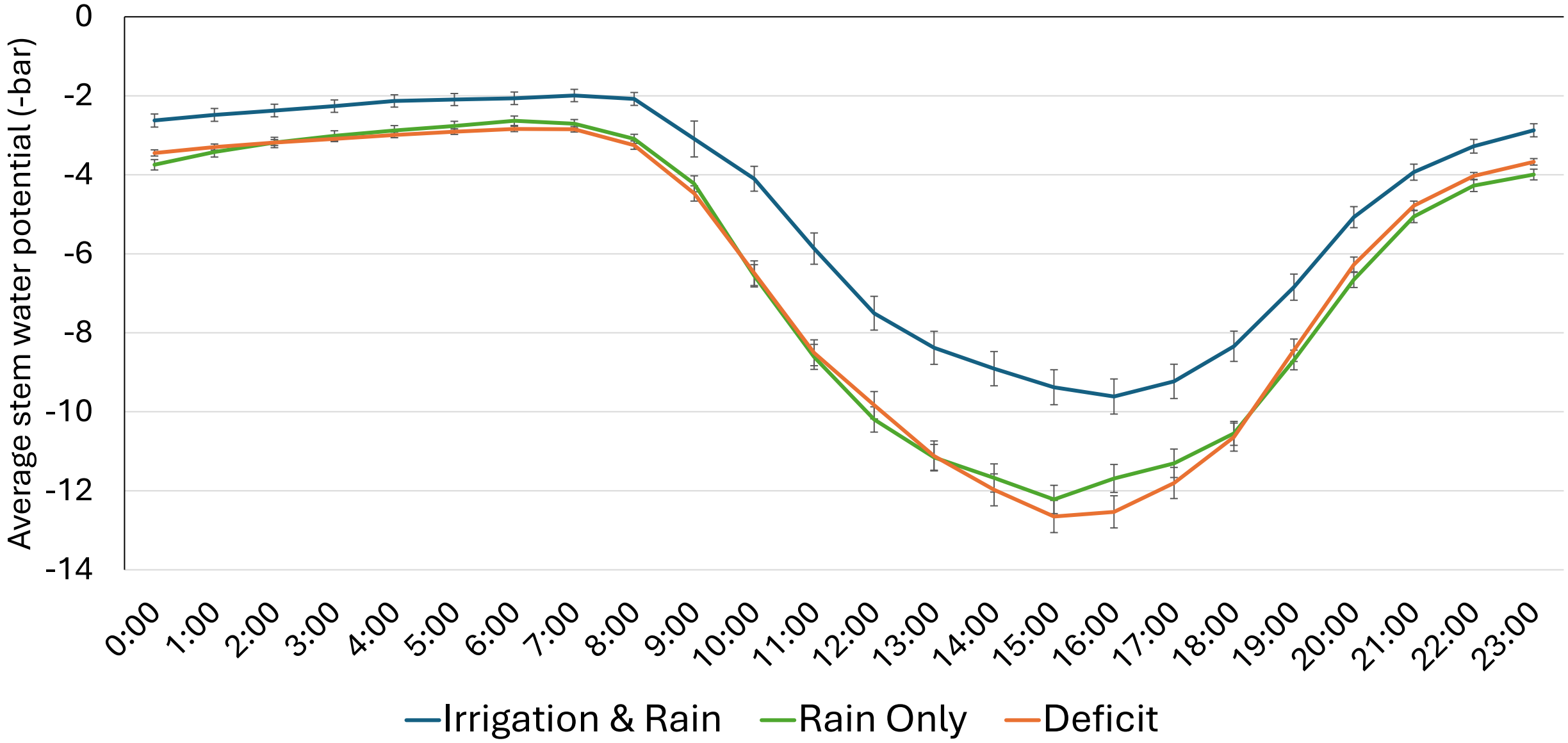
Precision hand thinning



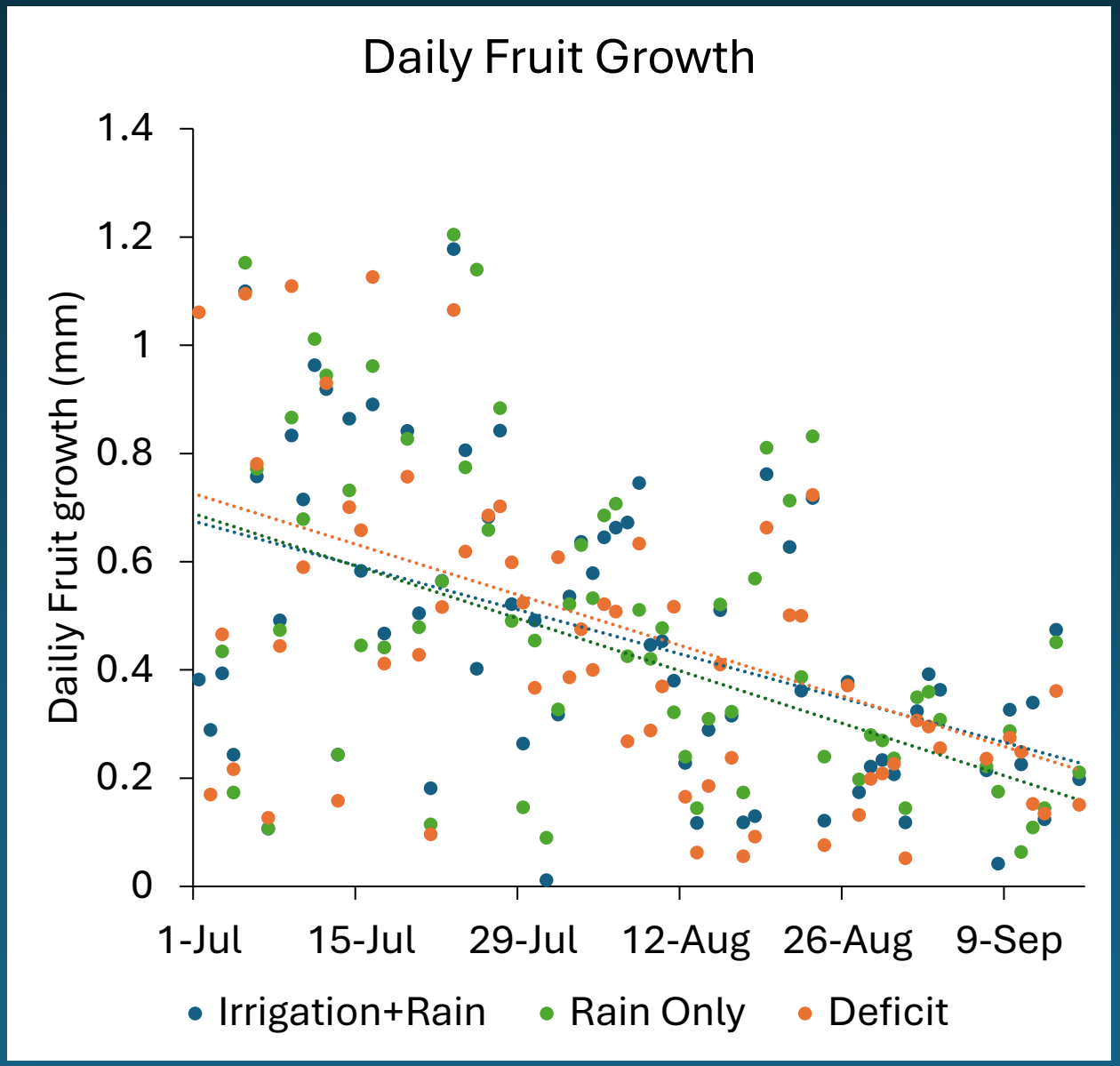
- In general, camera systems become more accurate with larger fruit on trees
- Hand thinning guided by fruit number maps can help reduce labor costs
- In 2025, a grower targeted highest area (red square) while leaving the rest of the block with little hand thinning
- Before hand thinning showed a large area with excessive number of fruits, after targeted hand thinning the map showed a more uniform number of fruits
- To more precisely manage hand thinning we need a method to guide human workers.

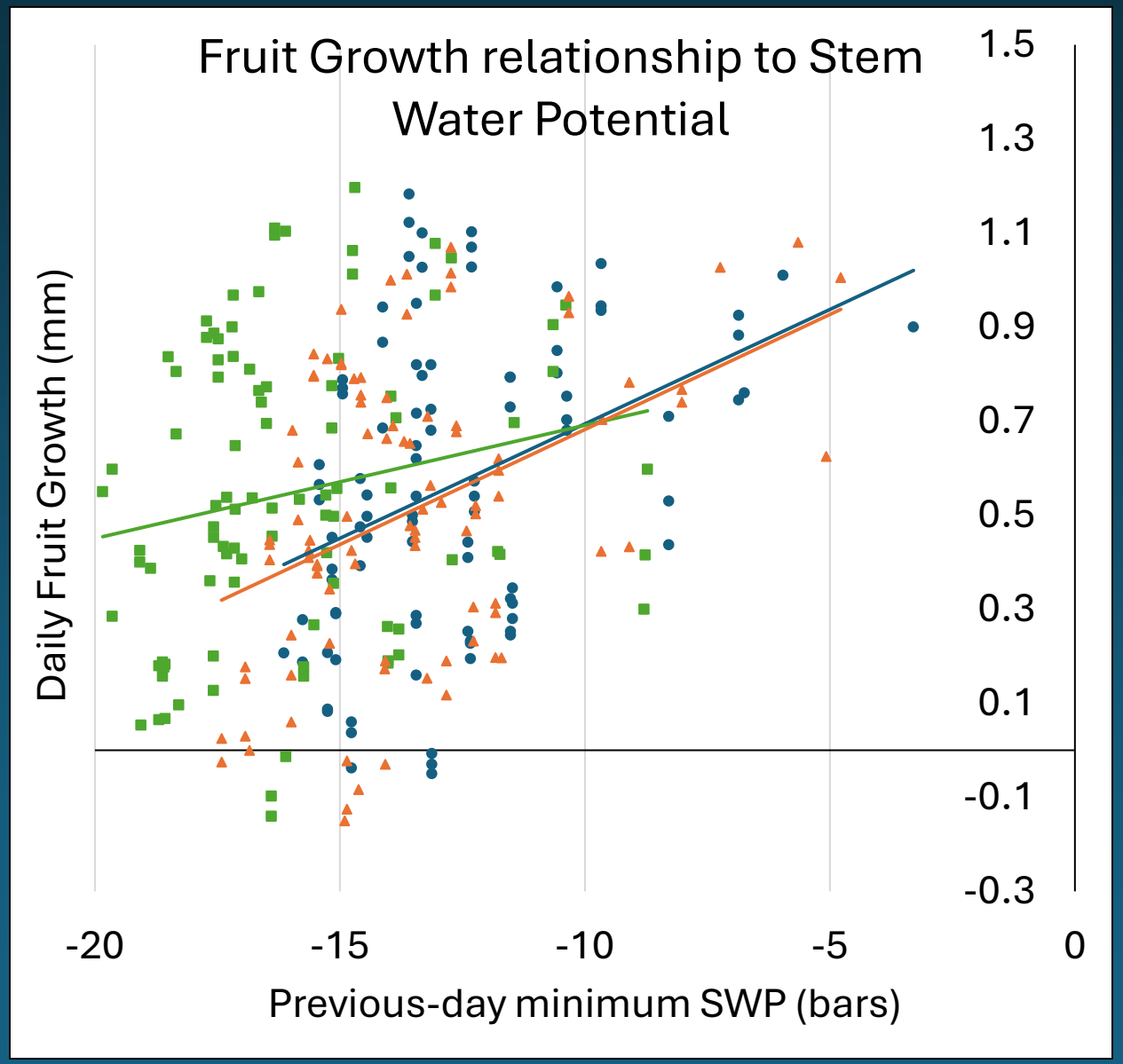
Precision orchard irrigation with microtensiometers

Diurnal stem water potential pattern

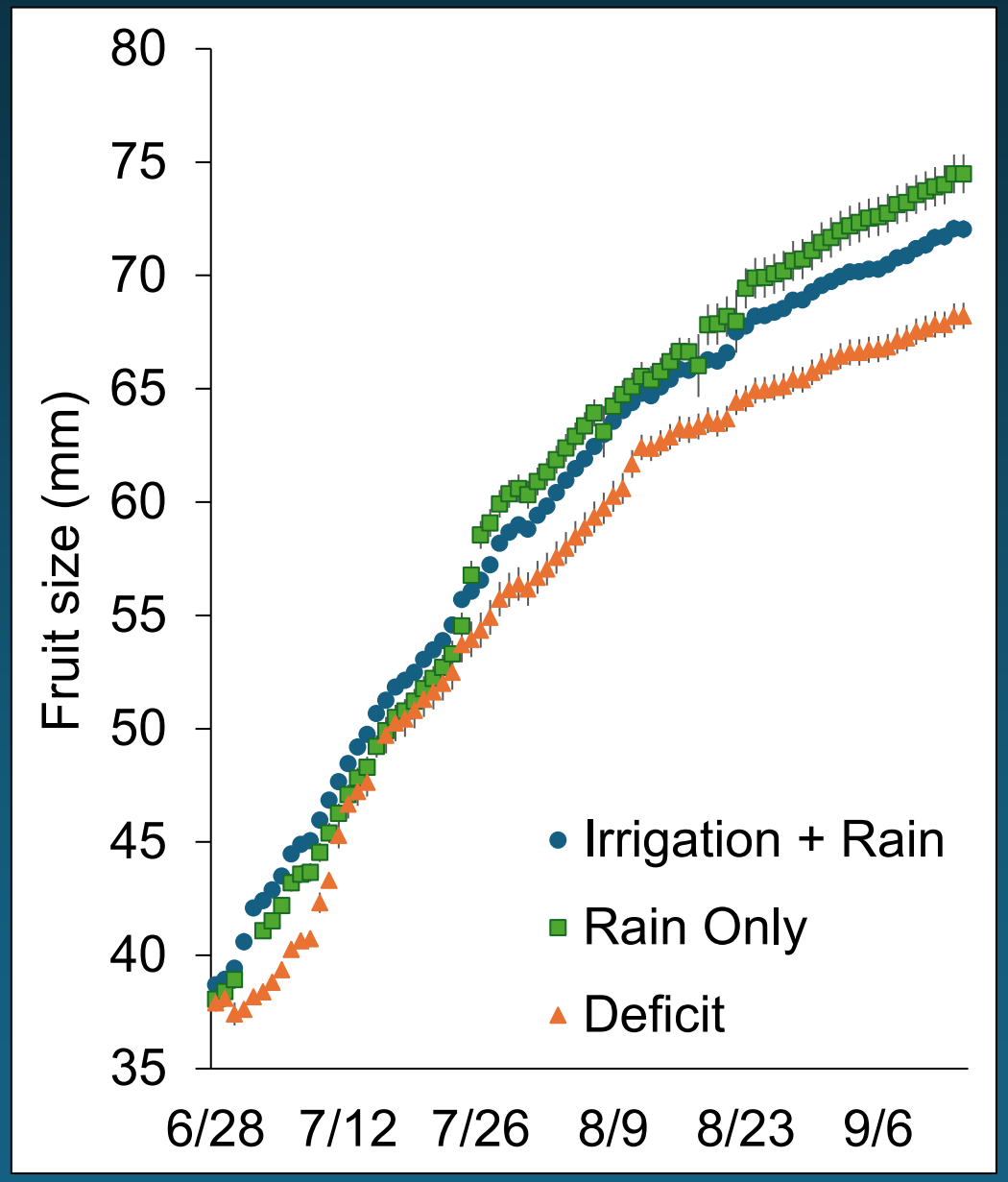


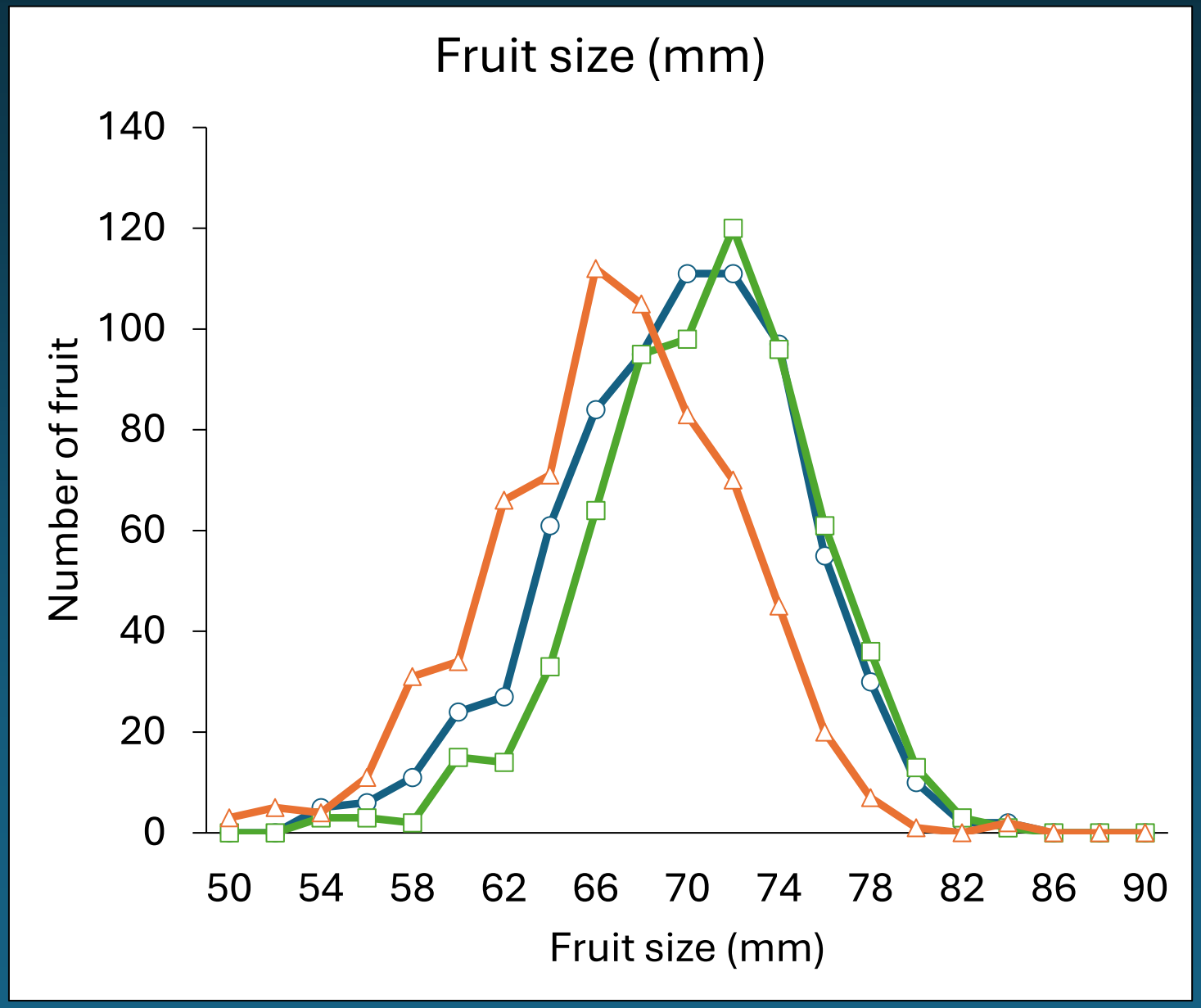
Daily Fruit Growth and relationship to Stem Water Potential



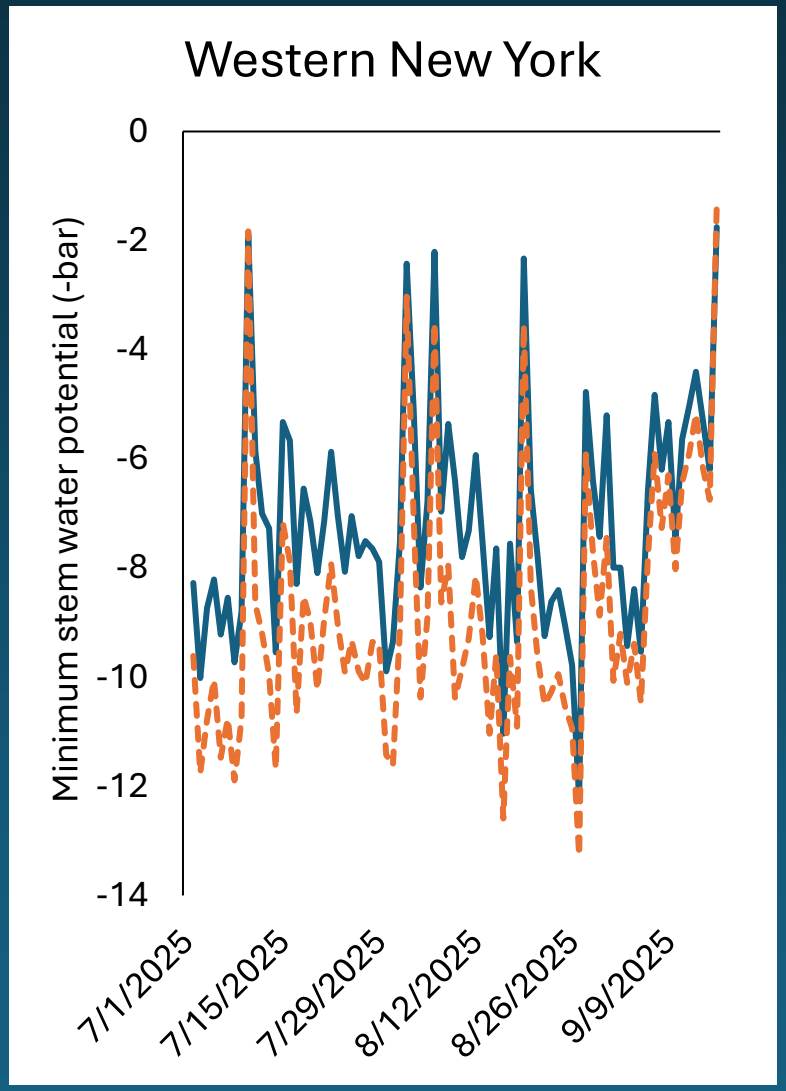


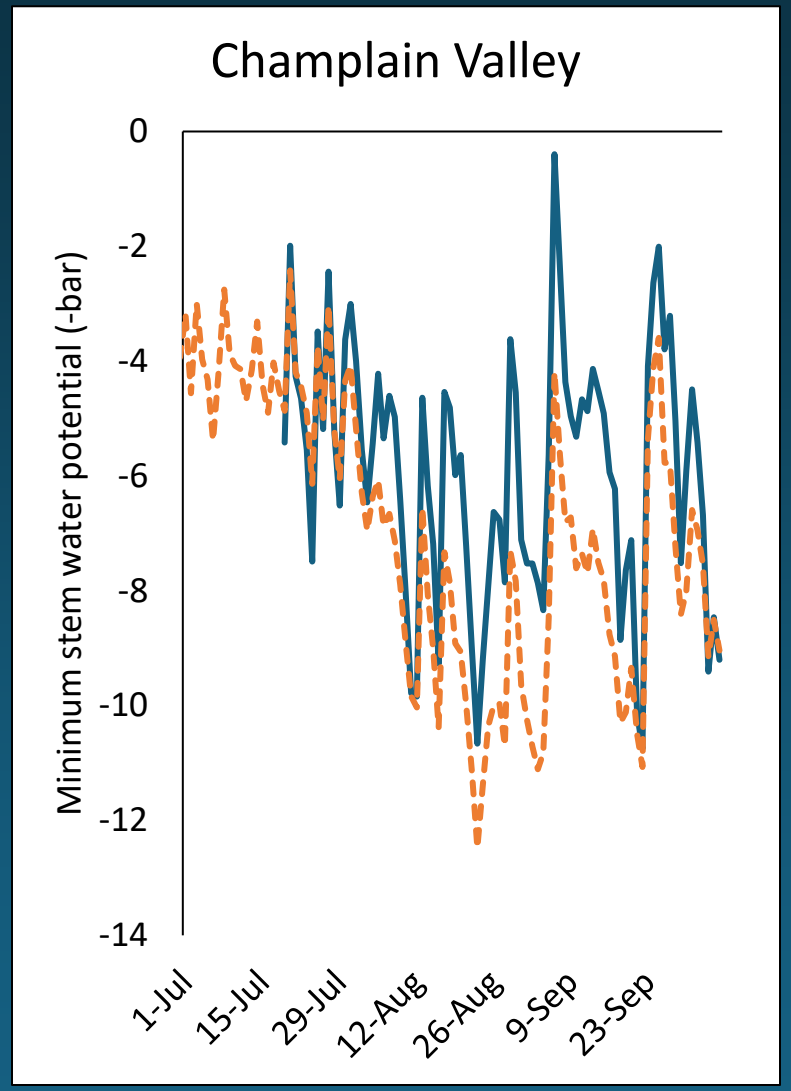
Gala fruit growth (June-harvest) and fruit size distribution

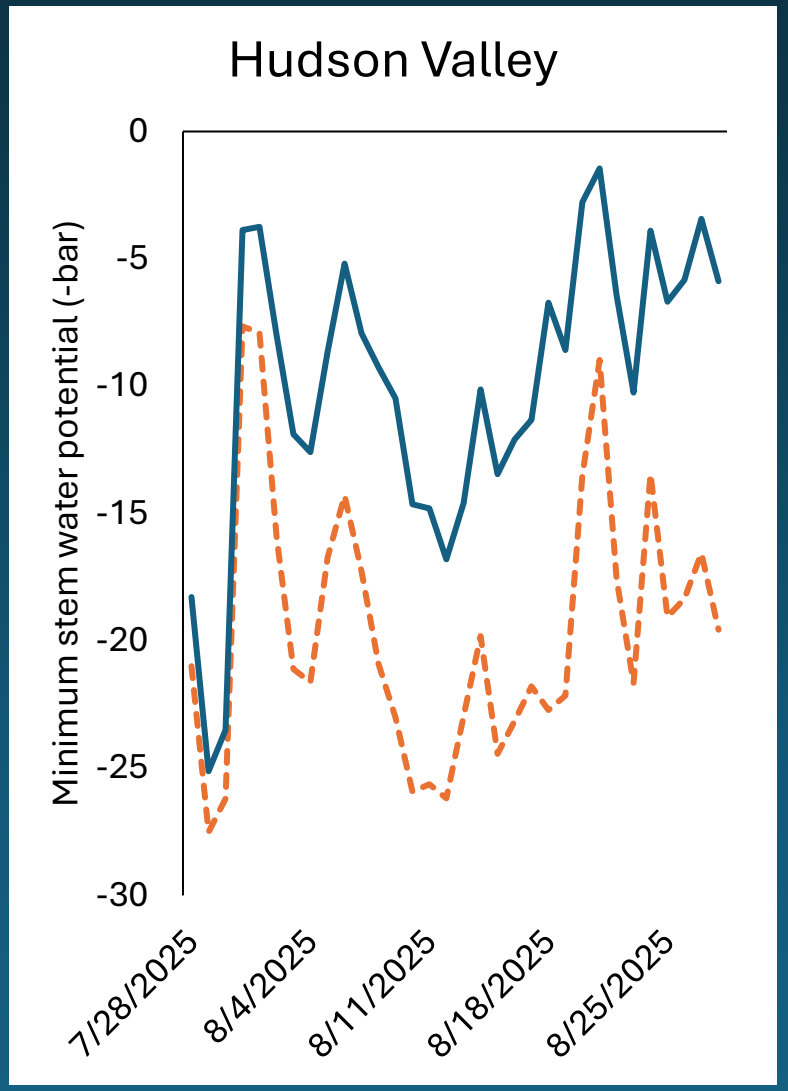




Microtensiometer readings across NY state in 2025







Irrigated
Unirrigated

Variable Rate Fertilizer Application

- We have evaluated ground-based mapping using electrical conductivity but have now shown important improvements in fruit quality.
- Now there are camera-based evaluations of tree vigor (canopy size) which can be used to more precisely map the orchard for variability in N to then use task maps with precision variable rate fertilizer spreaders.
- Multi-spectral cameras will likely allow mapping of orchards for Ca and K to allow variable rate fertilization based on precise maps.

How to Improve Profitability?

- Chose a high-priced variety.
- Plant the optimum density (2.5-3’ x 11-12’).
- Chose the right rootstock (Honeycrisp=G.969 or G.214, Snapdragon=G.257, or G.969 Gala=G.11 or G.41, Evercrisp (G.214, G.969, G.41 or G.11).
- Prune to target bud number (1.5X final fruit number).
- Use precision blossom and post bloom thinning.
- Use variable rate thinning whenever bloom is variable in a block.
- Use precision hand thinning.
- Use microtensiometers to manage irrigation and maximize fruit size.
- Use variable rate fertilizers based on precision maps to manage nutrient balance in the fruit for better storage performance.
- Improve fruit color with reflective film of PGR’s.
- Improve storage quality using PGR’s.