A Vision for Future Apple Orchards

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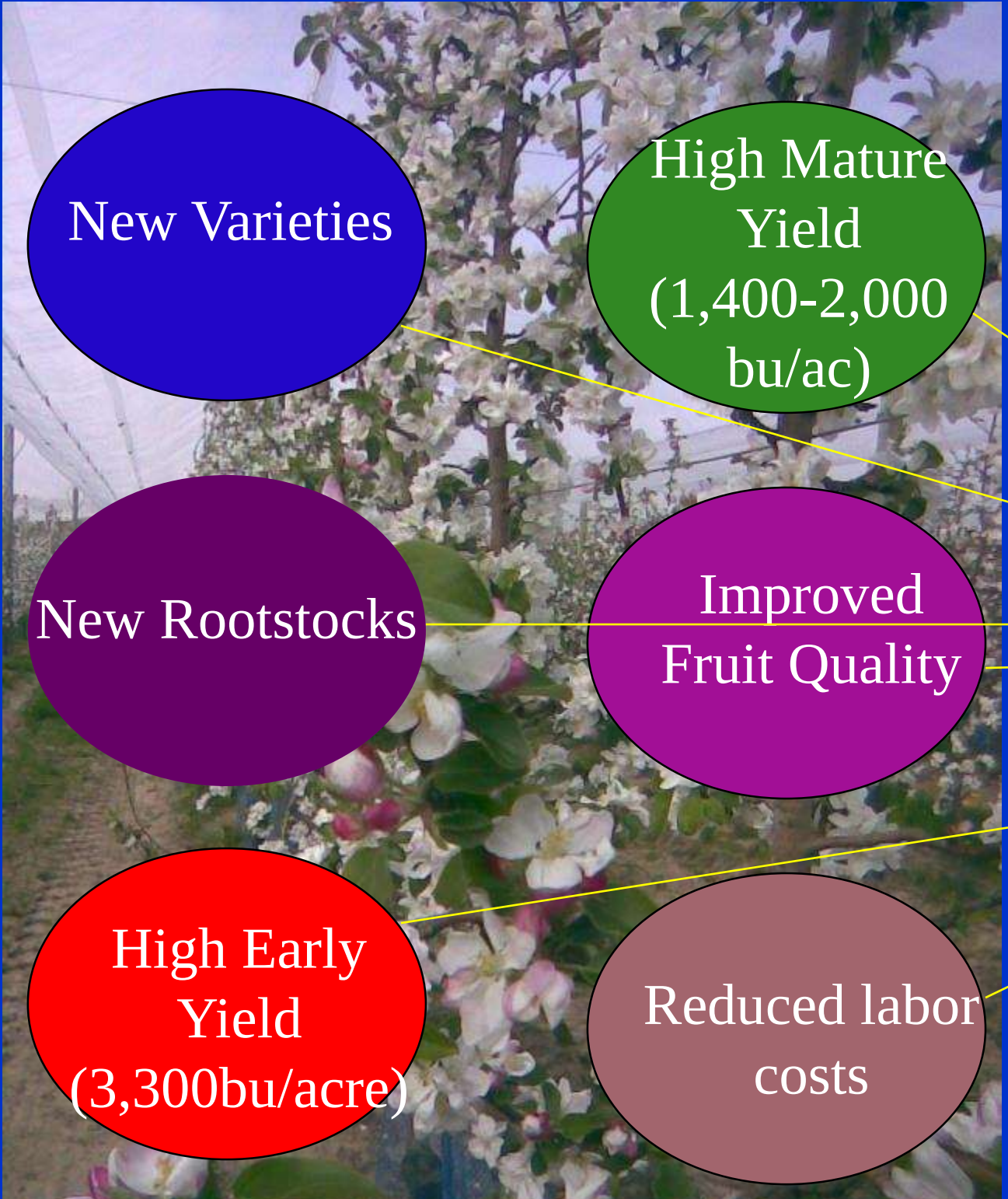
In the Last 50 Years Orchards Have Evolved from Multi-Leader Trees on Seedling Rootstocks at 40 Trees/Acre to the Tall Spindle on M.9

Where will we be in 20 more years?



There exists a confluence of technologies that make apple growing very interesting and profitable in 2019

New Varieties

High Mature Yield (1,400-2,000 bu/ac)

New Rootstocks

Improved Fruit Quality

High Early Yield (3,300bu/acre)

Reduced labor costs

A Vision for the orchard of the future

Collapse of market for traditional varieties

There is a rapidly shrinking market for
McIntosh,
Empire,
Red Delicious
Jonagold
Golden Delicious

For many growers this is a serious threat to their business plan and convinces some to leave apple growing.

However, there is an opportunity for great profitability with new varieties.

This requires new plantings with a high capital requirement.

New Varieties

Most are protected and grown in clubs

From New Zealand

- Jazz
- Envy
- Koru
- Sonya
- Sweetie

From USA

- Sweetango
- Snapdragon
- Pazzaz
- Riverbelle
- Cosmic Crisp
- Ruby Frost
- Evercrisp
- Sweetcheeks
- Premier Honeycrisp
- Barnsby Pink Lady

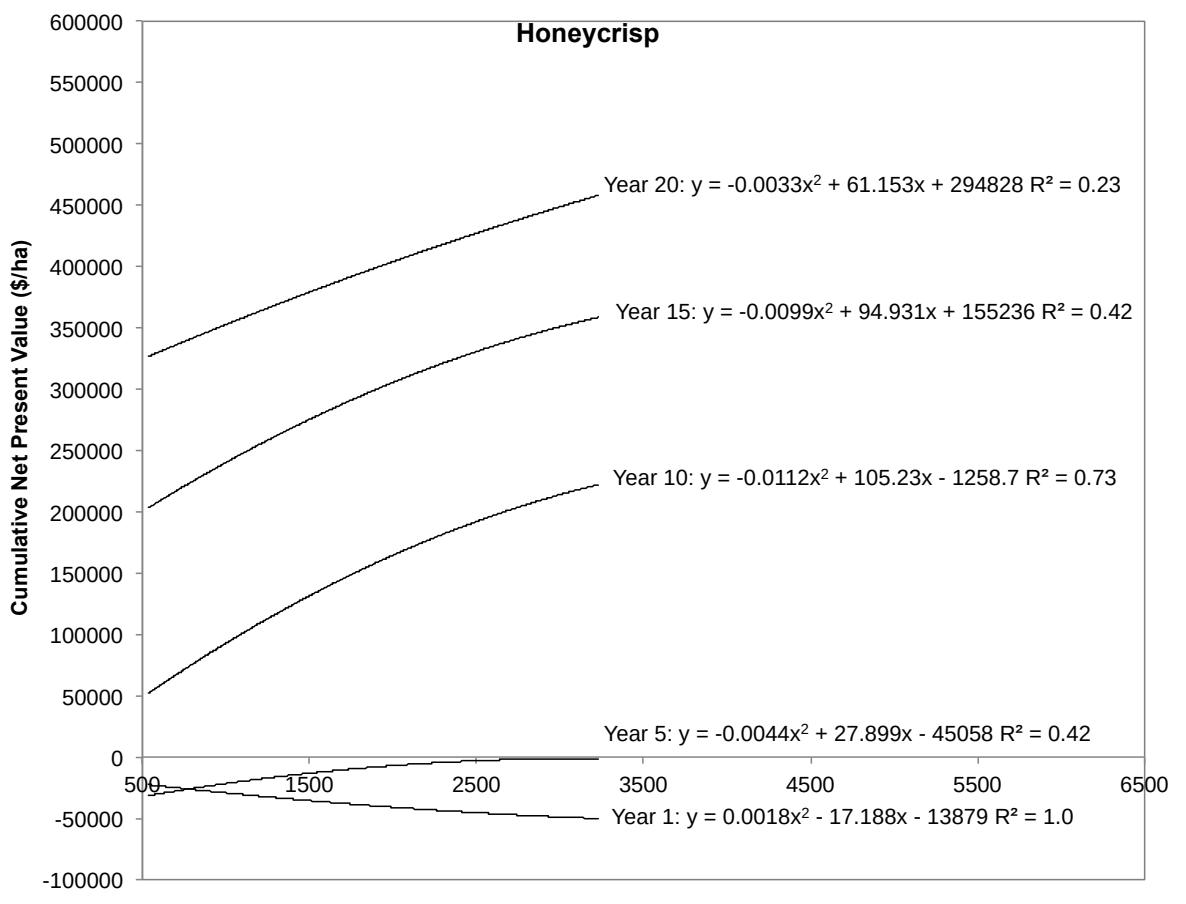
From Canada

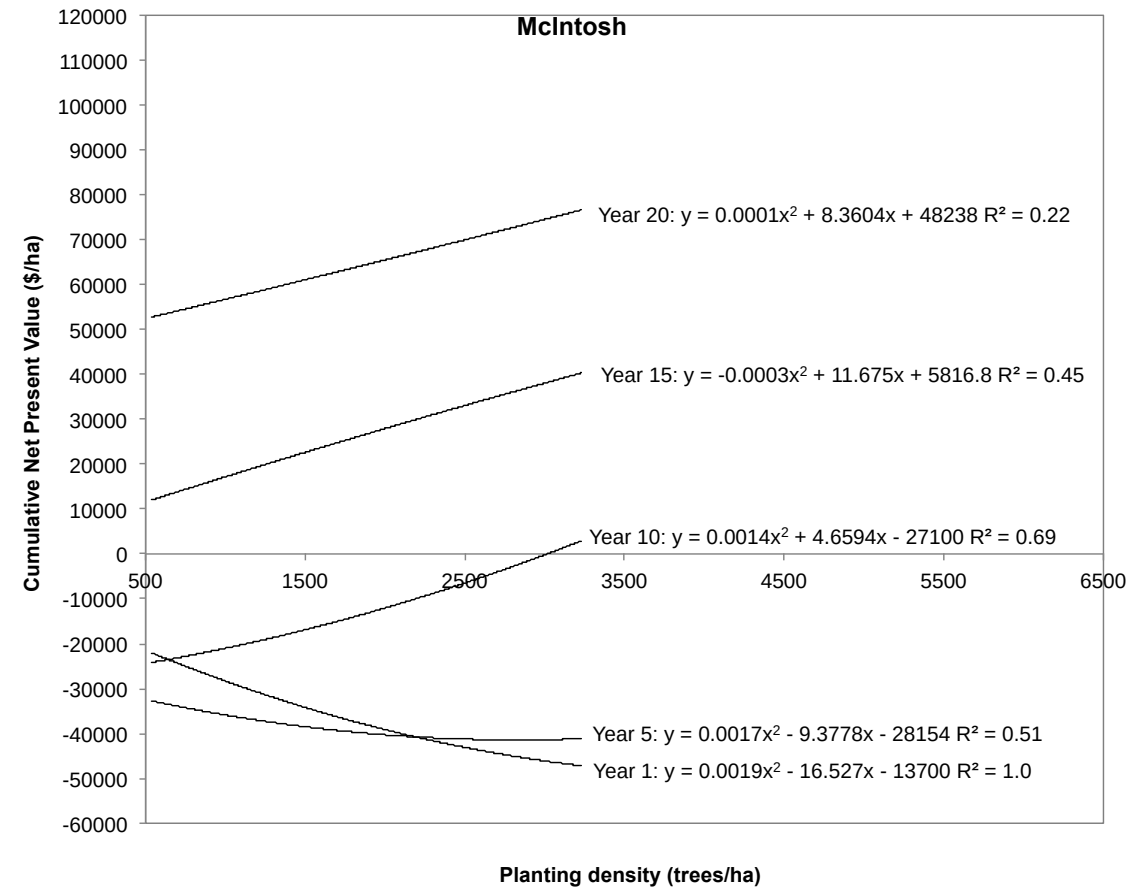
- Ambrosia

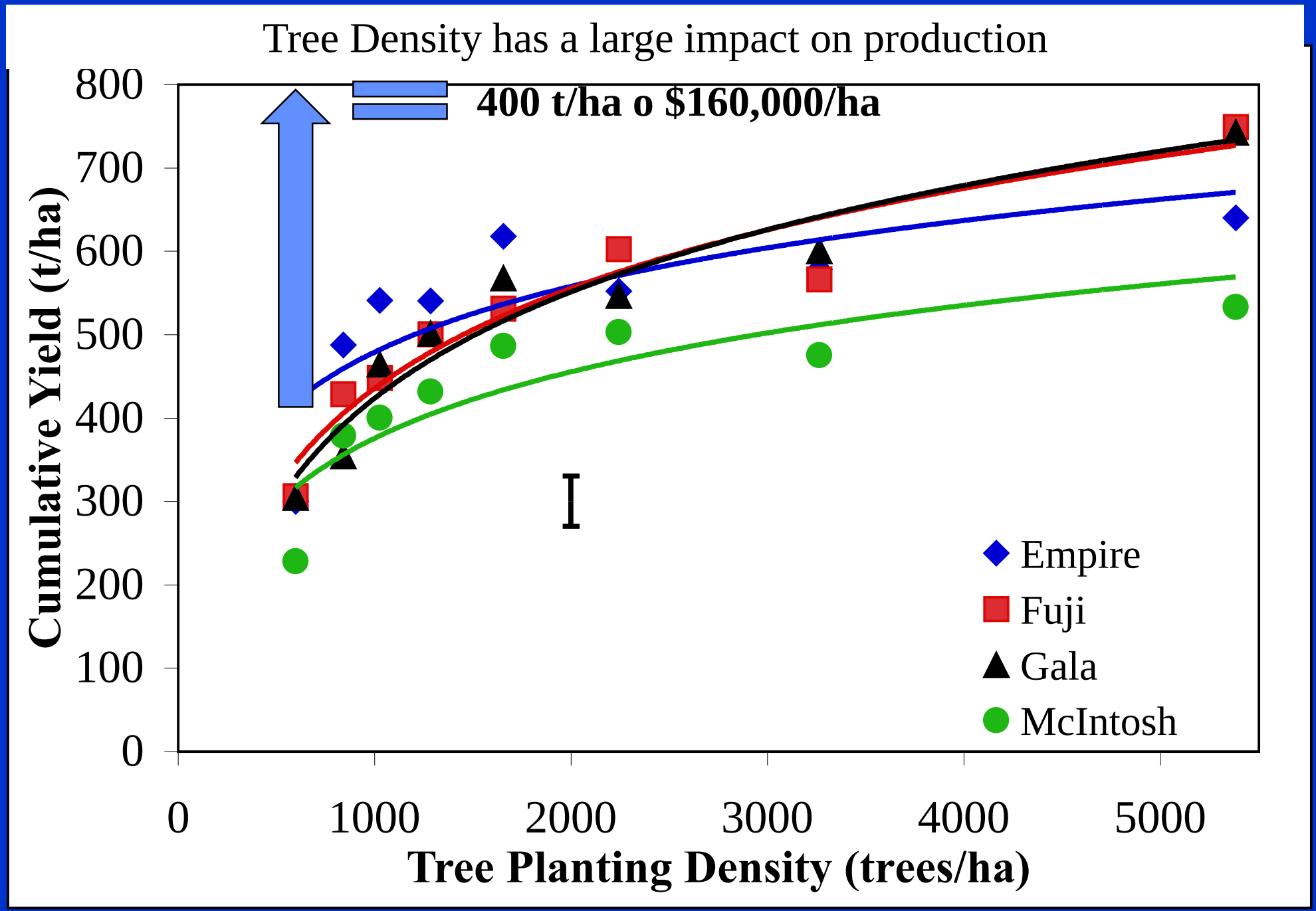
From Europe

- Red Flesh (Surprize)
- Kanzi
- Opal
- Pinova
- Tentation
- Modi

High Priced Varieties have Huge Impact on Profitability

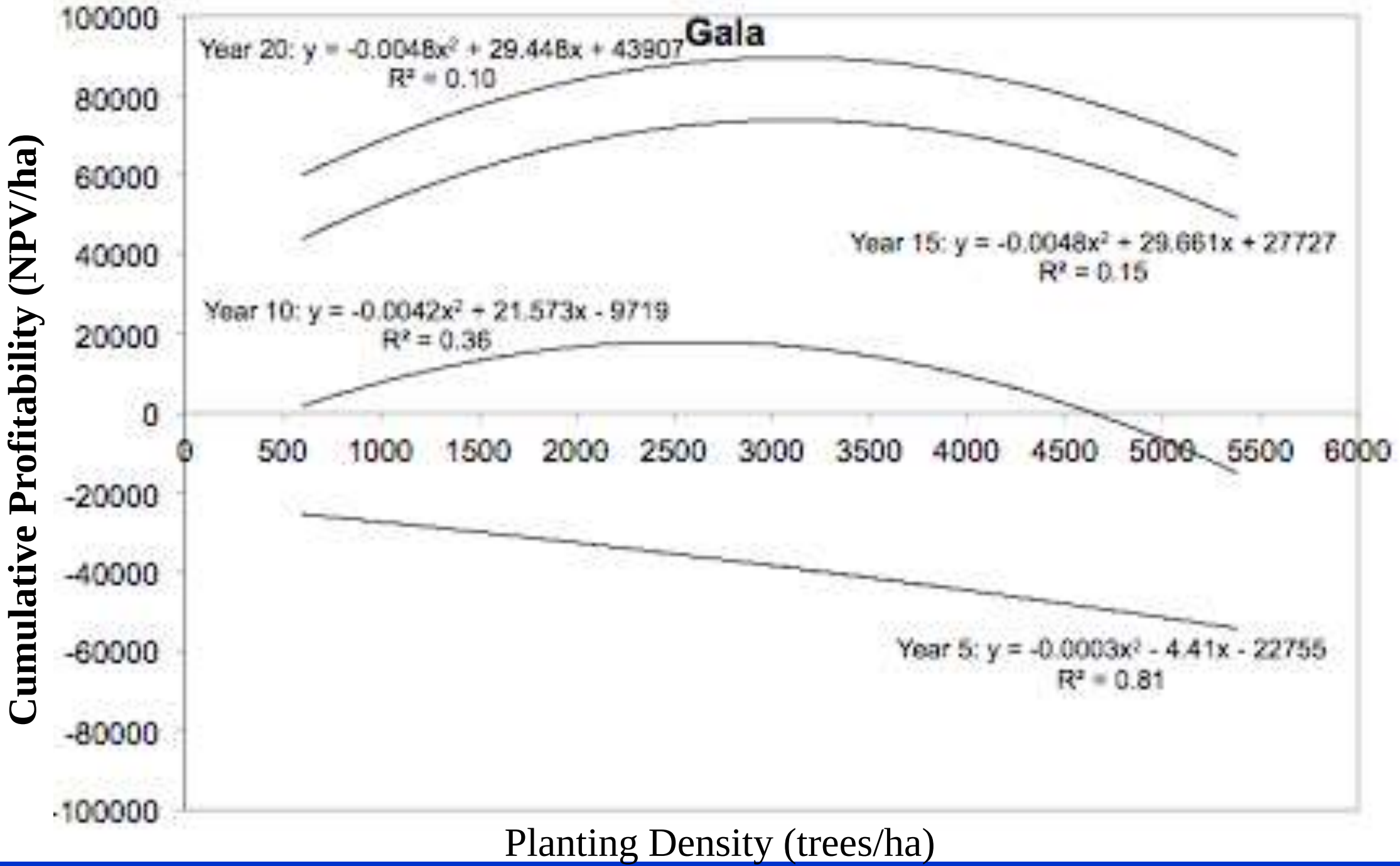






Cumulative production over the first 13 years of the highest density was 2 times greater than the lowest density

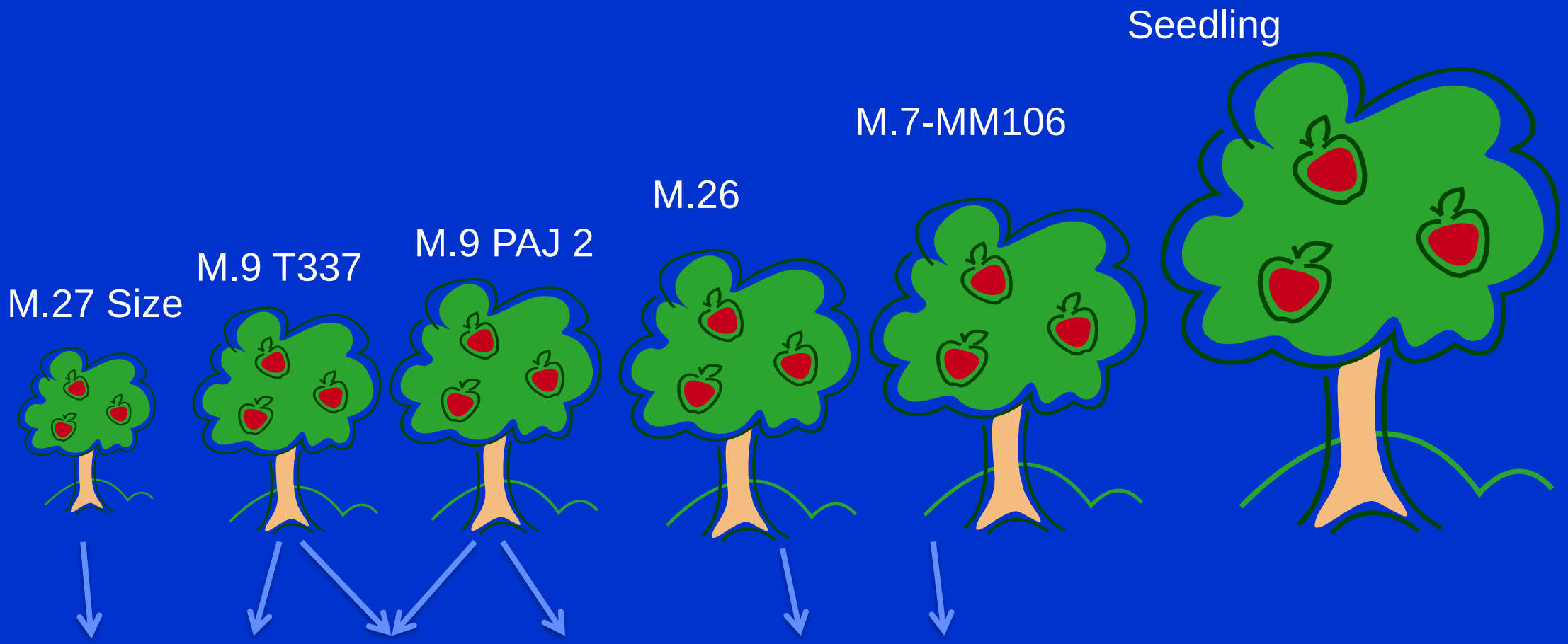
The optimum planting density is 3200 trees/ha (range 2800-4000)



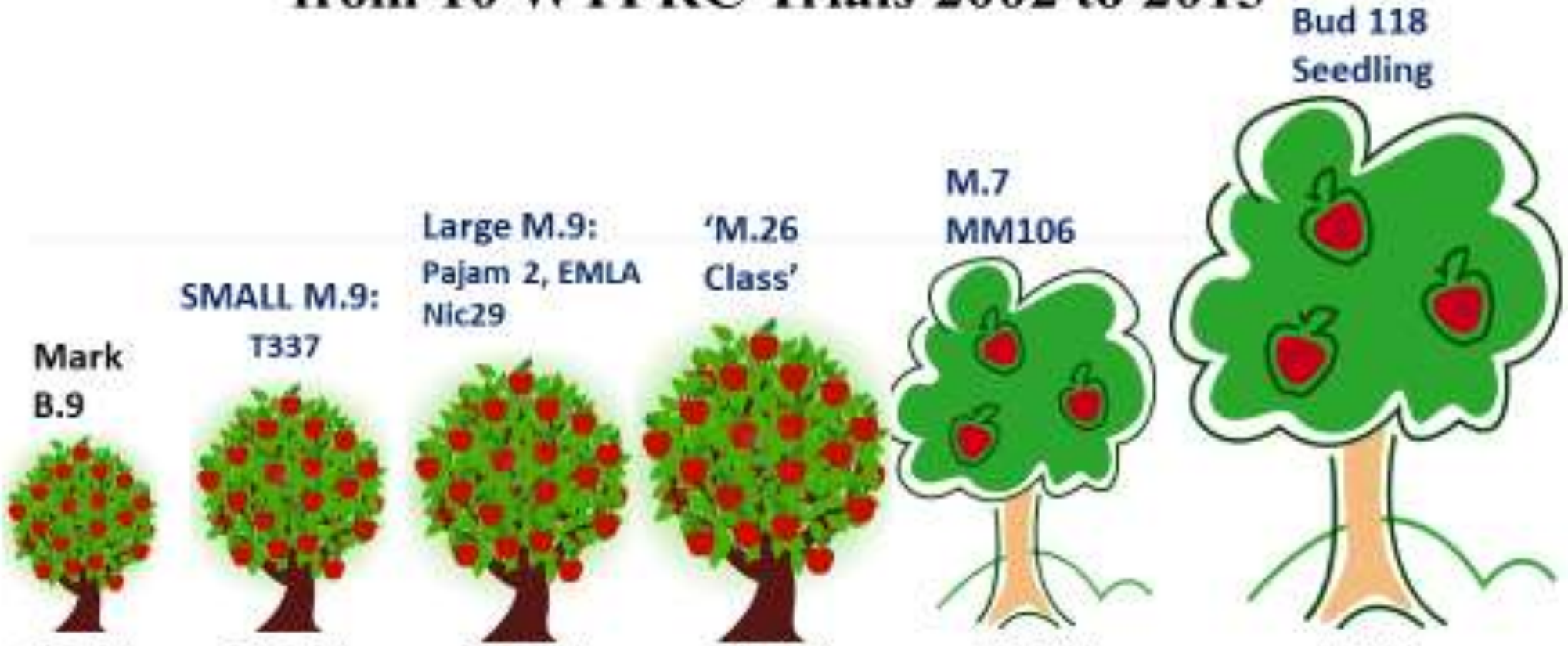
With Several New Rootstock Options of Varying Vigor Levels Selecting the Rootstock that Gives the Best Combination of Growth and Yield for the Variety We are Planting – Designer Rooststocks

- G.11, G.213 for strong varieties
- G.41 for weak varieties or replant
- G.935 or G.969 for very weak varieties
- G.202, G.969 or G.210 for organic

1. New Rootstocks from Geneva® which tolerate fire blight and replant disease



Geneva® Rootstocks by Tree Size from 10 WTFRC Trials 2002 to 2013



G.11	G.935	G.30
G.41	G.214	G.890
	G.210	G.969
	G.222	G.202
	G.16	

Modified for Washington State conditions from Terence Robinson, Cornell University; Gennaro Fazio, USDA-ARS

WASHINGTON TREE FRUIT RESEARCH COMMISSION

Dwarfing rootstocks for SW Michigan

- G.11
- G.213
- G.41
- G.214
- G.935
- G.814
- G.202
- G.969
- G.210
- G.890

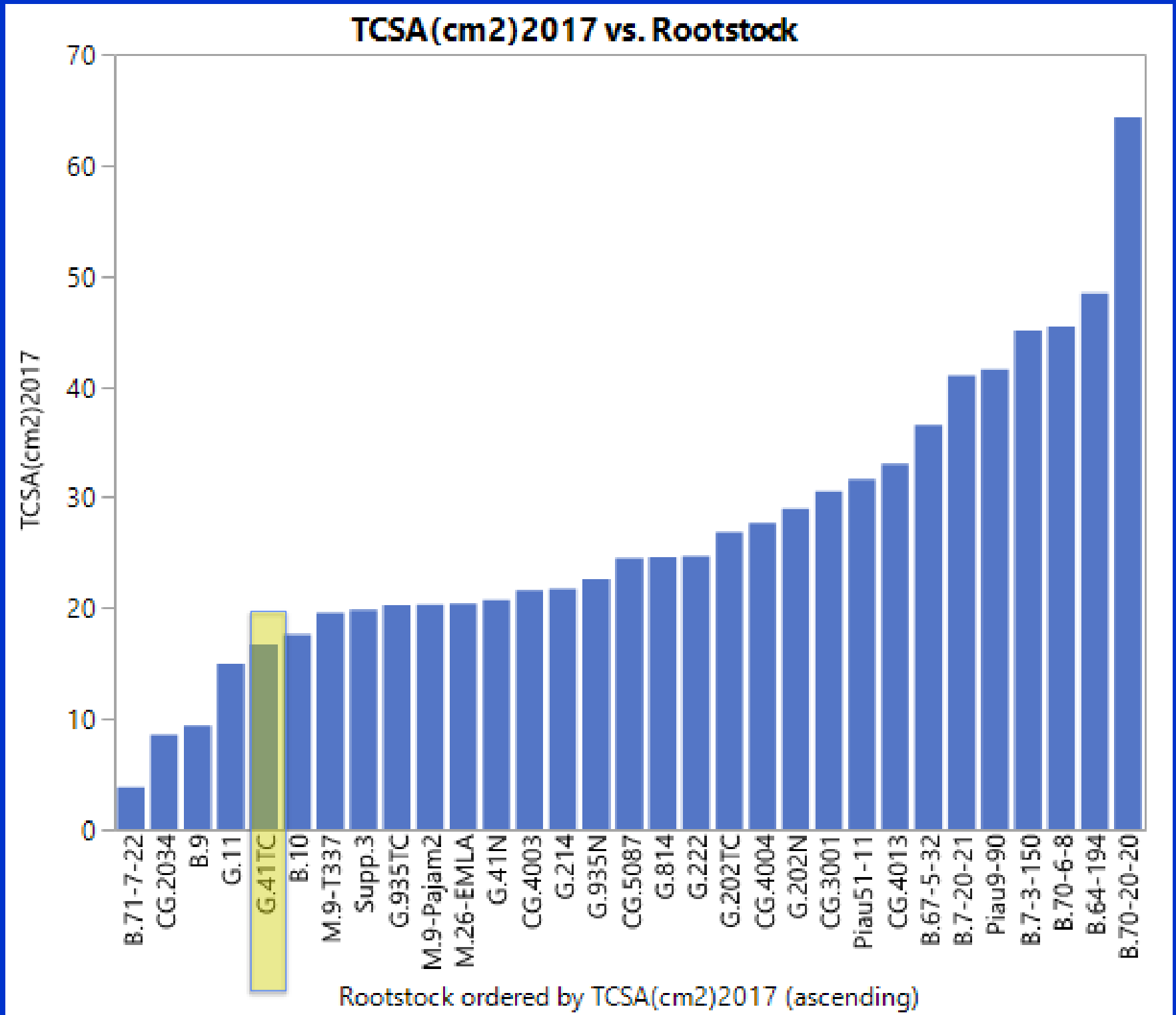
G.213

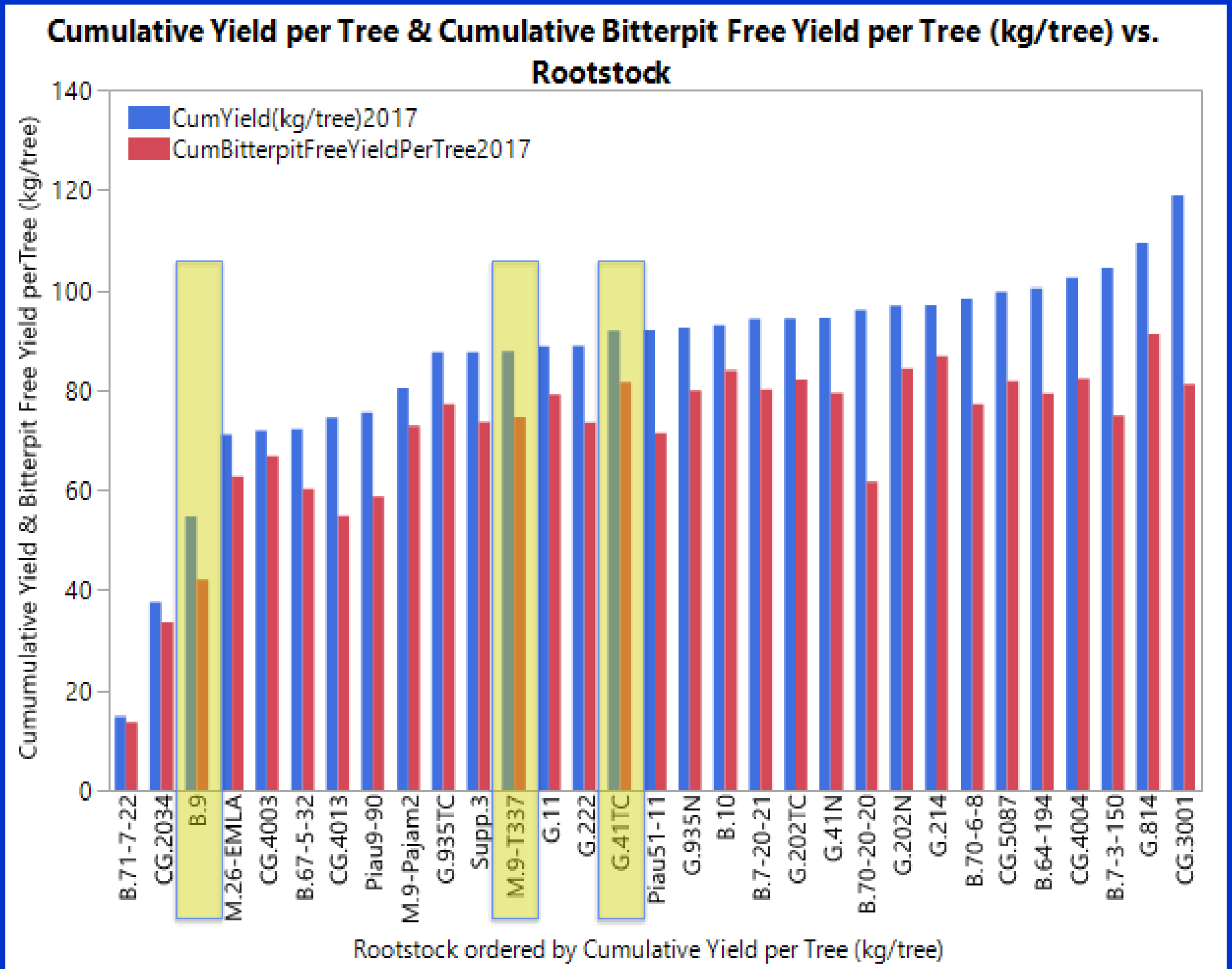
- Vigor similar to M.9 Paj.2
- Good yield efficiency
- High productivity 125% of M.9
- Very good precocity
- Resistant to Fire Blight, Crown Rot and Wooly Apple Aphid
- Replant tolerant
- Some spines in stool bed propagation
- Reduced chill requirement

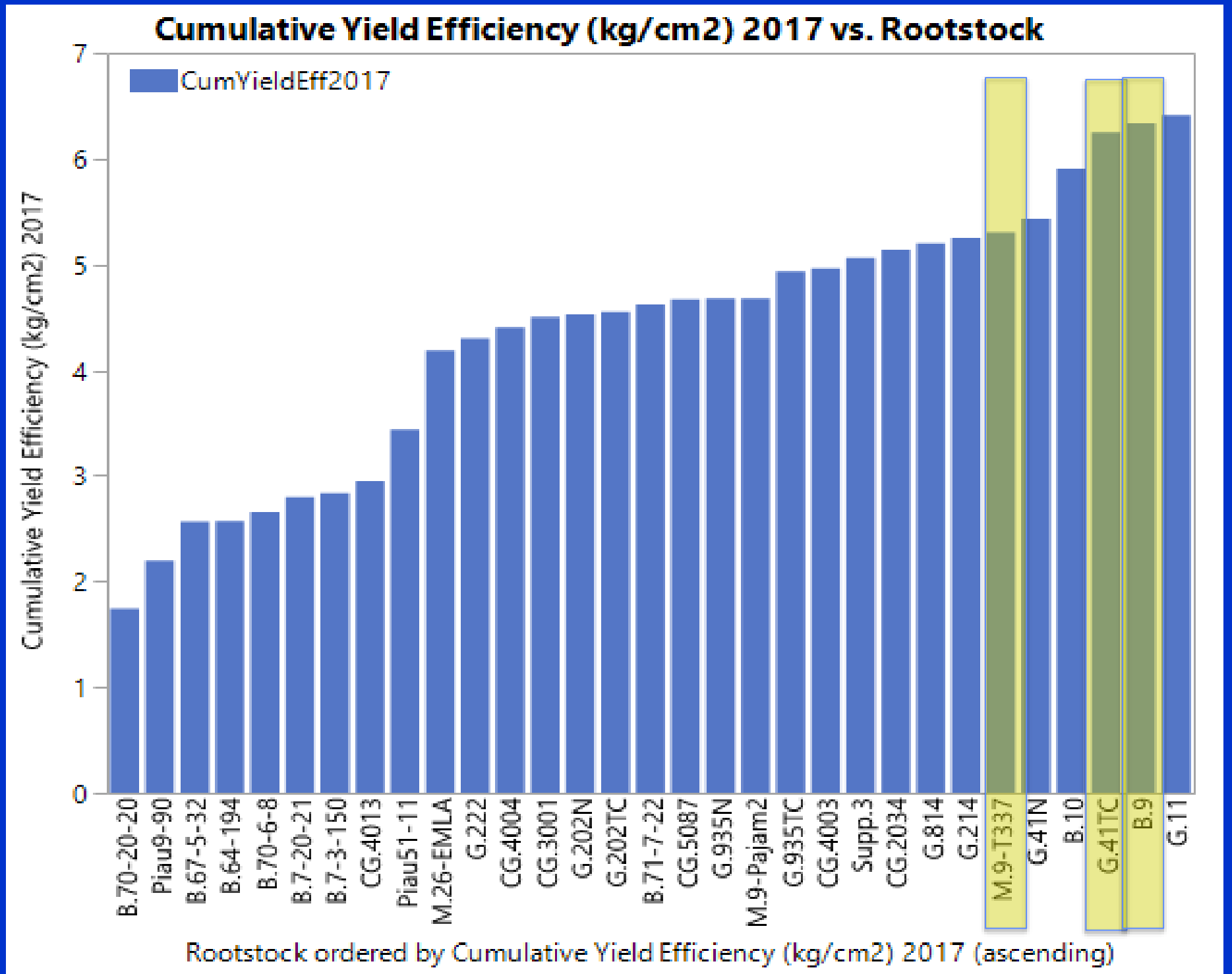
G.213 Vacaria, Brazil

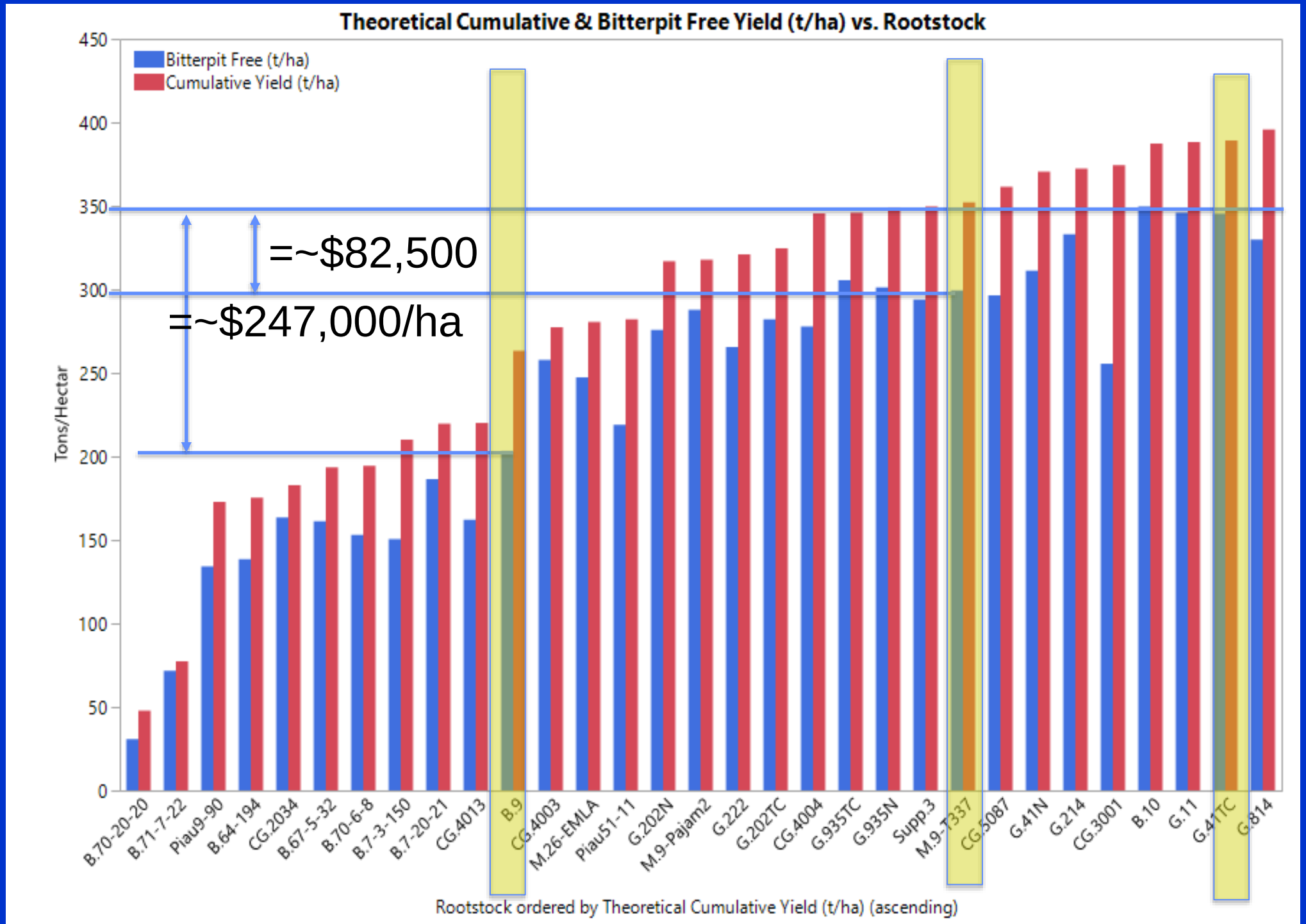
G.41

- M.9 Pajam2 vigor
- Very high yield efficiency
- Highly productive
- Very precocious
- Resistant to replant disease
- Very cold hardy
- Does well in warmer climates (Mexico)
- Highly Resistant to Fire Blight and Crown Rot and Wooly Apple Aphid
- Difficult to propagate
- Brittle graft union with some cultivars

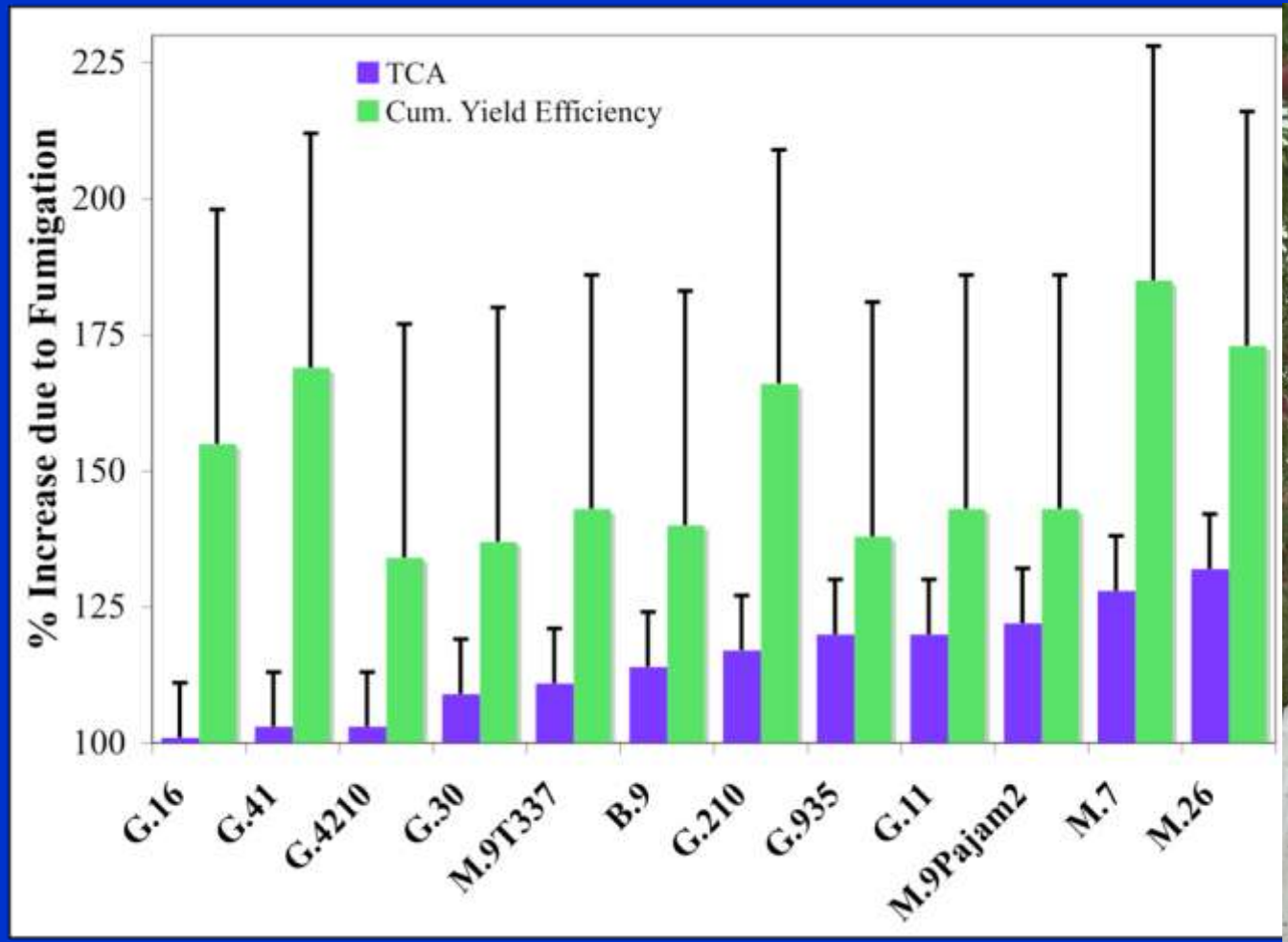

TCSA(cm2)2017 vs. Rootstock
TCSA(cm2)2017
70
60
50
40
30
20
10
0
B.71-7-22
CG.2034
B.9
G.11
G.41TC
B.10
M.9-T337
Supp.3
G.935TC
M.9-Pajam2
M.26-EMLA
G.41N
CG.4003
G.214
G.935N
CG.5087
G.814
G.222
G.202TC
CG.4004
G.202N
CG.3001
Piau51-11
CG.4013
B.67-5-32
B.7-20-21
Piau9-90
B.7-3-150
B.70-6-8
B.64-194
B.70-20-20
Rootstock ordered by TCSA(cm2)2017 (ascending)


Cumulative Yield per Tree & Cumulative Bitterpit Free Yield per Tree (kg/tree) vs. Rootstock
CumYield(kg/tree)2017
CumBitterpitFreeYieldPerTree2017
Cumumulative Yield & Bitterpit Free Yield perTree (kg/tree)
140
120
100
80
60
40
20
0
B.71-7-22
CG.2034
B.9
M.26-EMLA
CG.4003
B.67-5-32
CG.4013
Piau9-90
M.9-Pajam2
G.935TC
Supp.3
M.9-T337
G.11
G.222
G.41TC
Piau51-11
G.935N
B.10
B.7-20-21
G.202TC
G.41N
B.70-20-20
G.202N
G.214
B.70-6-8
CG.5087
B.64-194
CG.4004
B.7-3-150
G.814
CG.3001
Rootstock ordered by Cumulative Yield per Tree (kg/tree)


Cumulative Yield Efficiency (kg/cm2) 2017 vs. Rootstock
CumYieldEff2017
Cumulative Yield Efficiency (kg/cm2) 2017
0
1
2
3
4
5
6
7
B.70-20-20
Piau9-90
B.67-5-32
B.64-194
B.70-6-8
B.7-20-21
B.7-3-150
CG.4013
Piau51-11
M.26-EMLA
G.222
CG.4004
CG.3001
G.202N
G.202TC
B.71-7-22
CG.5087
G.935N
M.9-Pajam2
G.935TC
CG.4003
Supp.3
CG.2034
G.814
G.214
M.9-T337
G.41N
B.10
G.41TC
B.9
G.11
Rootstock ordered by Cumulative Yield Efficiency (kg/cm2) 2017 (ascending)


Theoretical Cumulative & Bitterpit Free Yield (t/ha) vs. Rootstock
Bitterpit Free (t/ha)
Cumulative Yield (t/ha)
=~$82,500
=~$247,000/ha
Tons/Hectar
0
50
100
150
200
250
300
350
400
450
B.70-20-20
B.71-7-22
Piau9-90
B.64-194
CG.2034
B.67-5-32
B.70-6-8
B.7-3-150
B.7-20-21
CG.4013
B.9
CG.4003
M.26-EMLA
Piau51-11
G.202N
M.9-Pajam2
G.222
G.202TC
CG.4004
G.935TC
G.935N
Supp.3
M.9-T337
CG.5087
G.41N
G.214
CG.3001
B.10
G.11
G.41TC
G.814
Rootstock ordered by Theoretical Cumulative Yield (t/ha) (ascending)

Several Geneva® Rootstocks Tolerate Replant Disease



G.214

- Vigor similar to M.9 Paj.2
- Highly yield efficient
- Highly productive (most U.S. trials yields 125% of M.9 check)
- Good precocity
- Resistant to Fire Blight, Crown Rot and Wooly Apple Aphid
- Replant tolerant
- Very good stool bed propagation
- Strong Graft Union

G.814

- Size similar to M.26
- Precocious, productive
- Promotes larger fruit size
- Horizontal branches
- Immune to fire blight, and resistant to crown rot
- Very tolerant to apple replant disease
- Susceptible to Wooly Apple Aphid
- Very susceptible to viruses (ASPV, ASGV, ACLV)
- Good rooting in stoolbed


G.935 Torres Fuji Virus

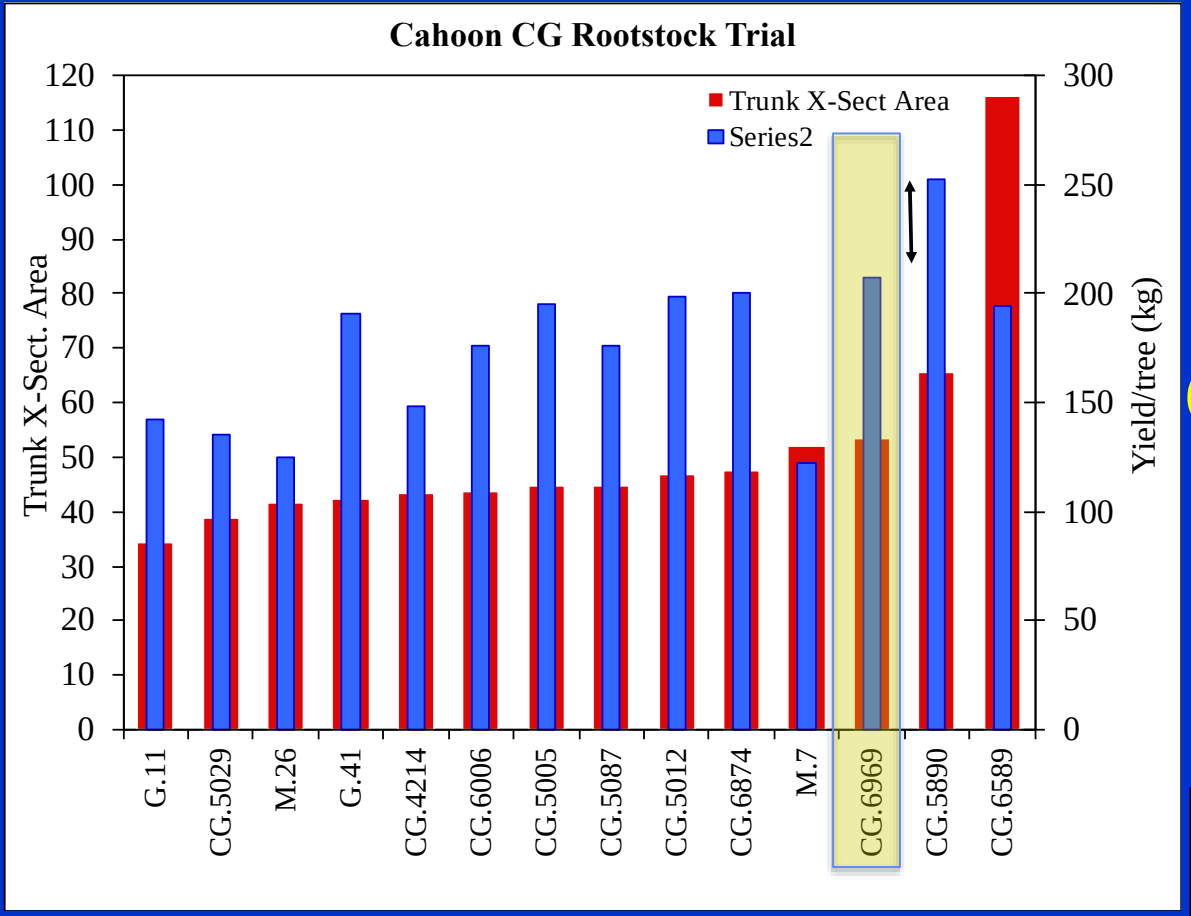

G.814 Torres Fuji Virus

G.202

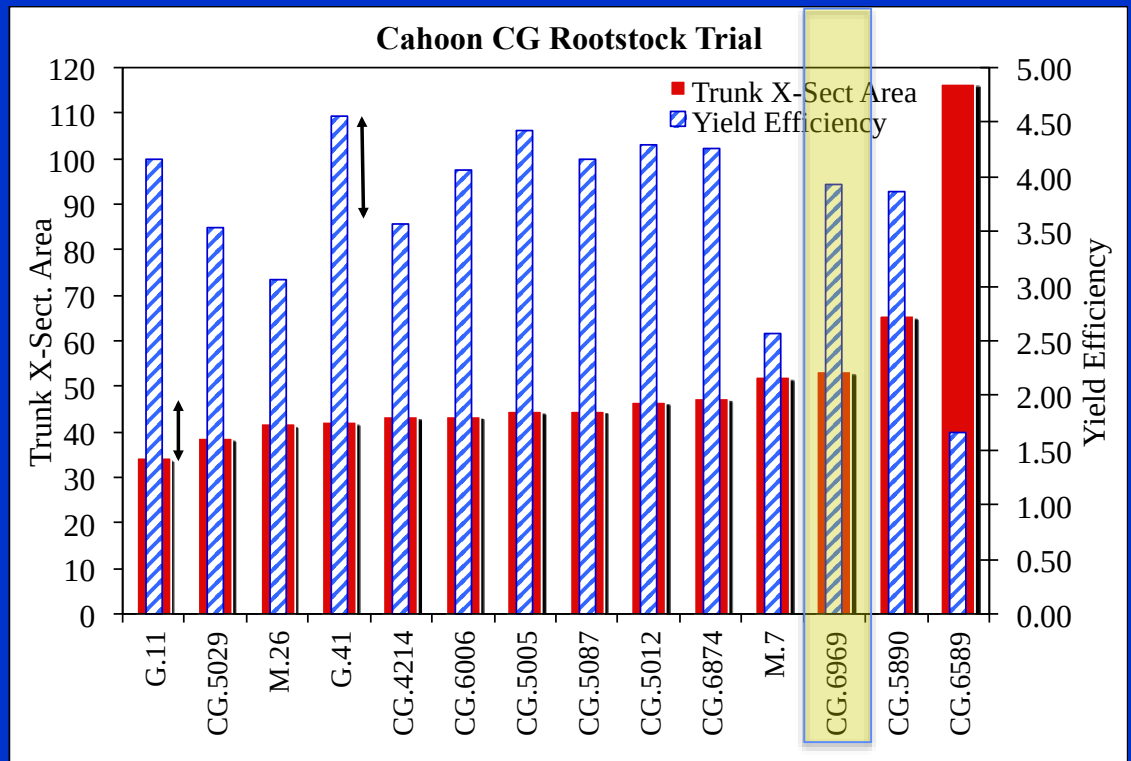
- Size similar to M.26
- Precocious, productive
- Resistant to woolly apple aphid, fire blight, and crown rot
- Tolerant to apple replant disease
- Good choice for weak growing cultivars like Honeycrisp
- Moderate rooting in stoolbed

G.969

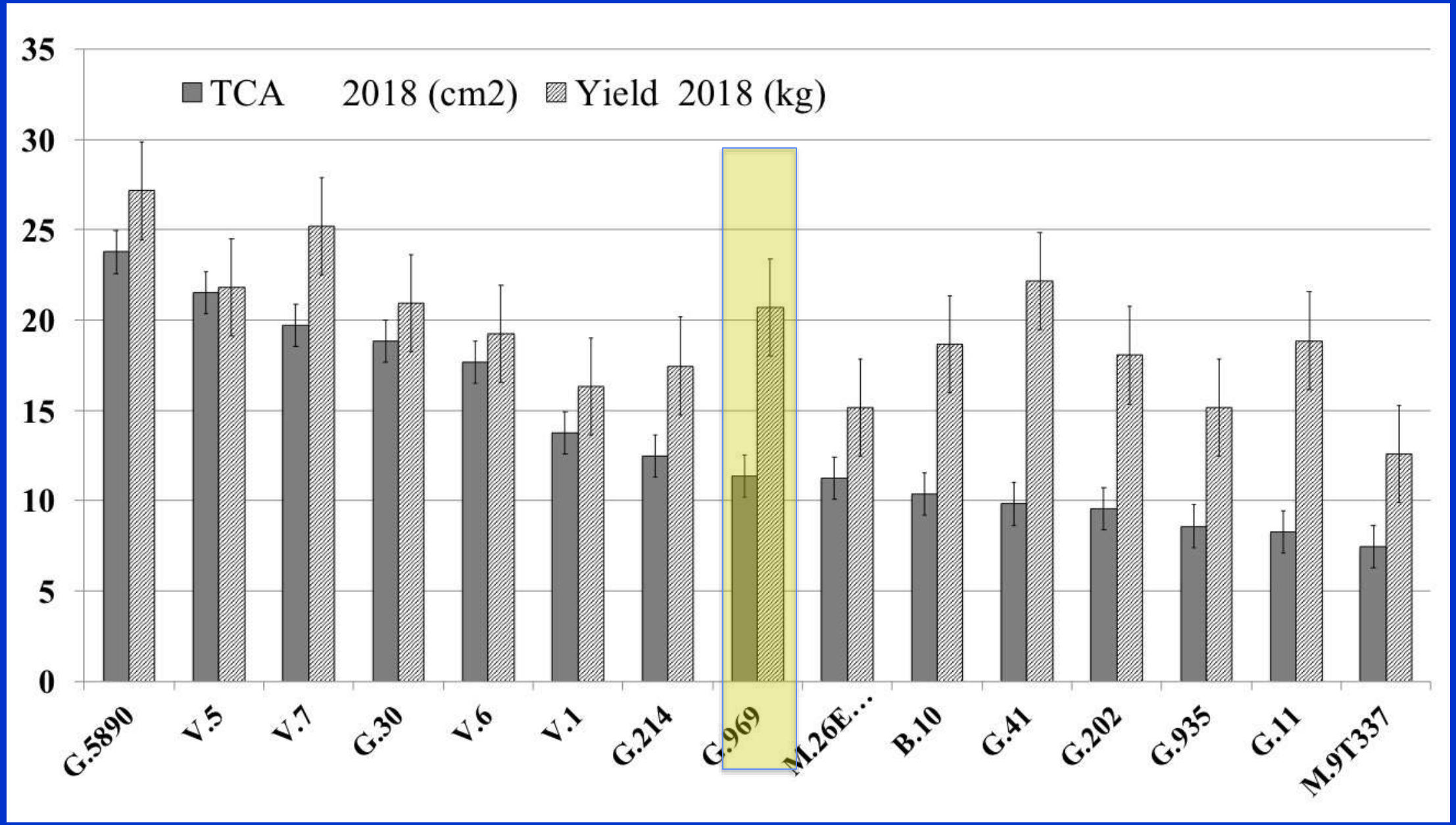
- Vigor between M.26 y M.7
- Very efficient and productive
- Very cold tolerant
- Resistant to fire blight
- Resistant to Phytopthora
- Resistant to Wolly Apple Aphid
- Good Anchorage
- Excellent rootstock for weak scions like Honeycrisp



Golden Delicious after 8 years

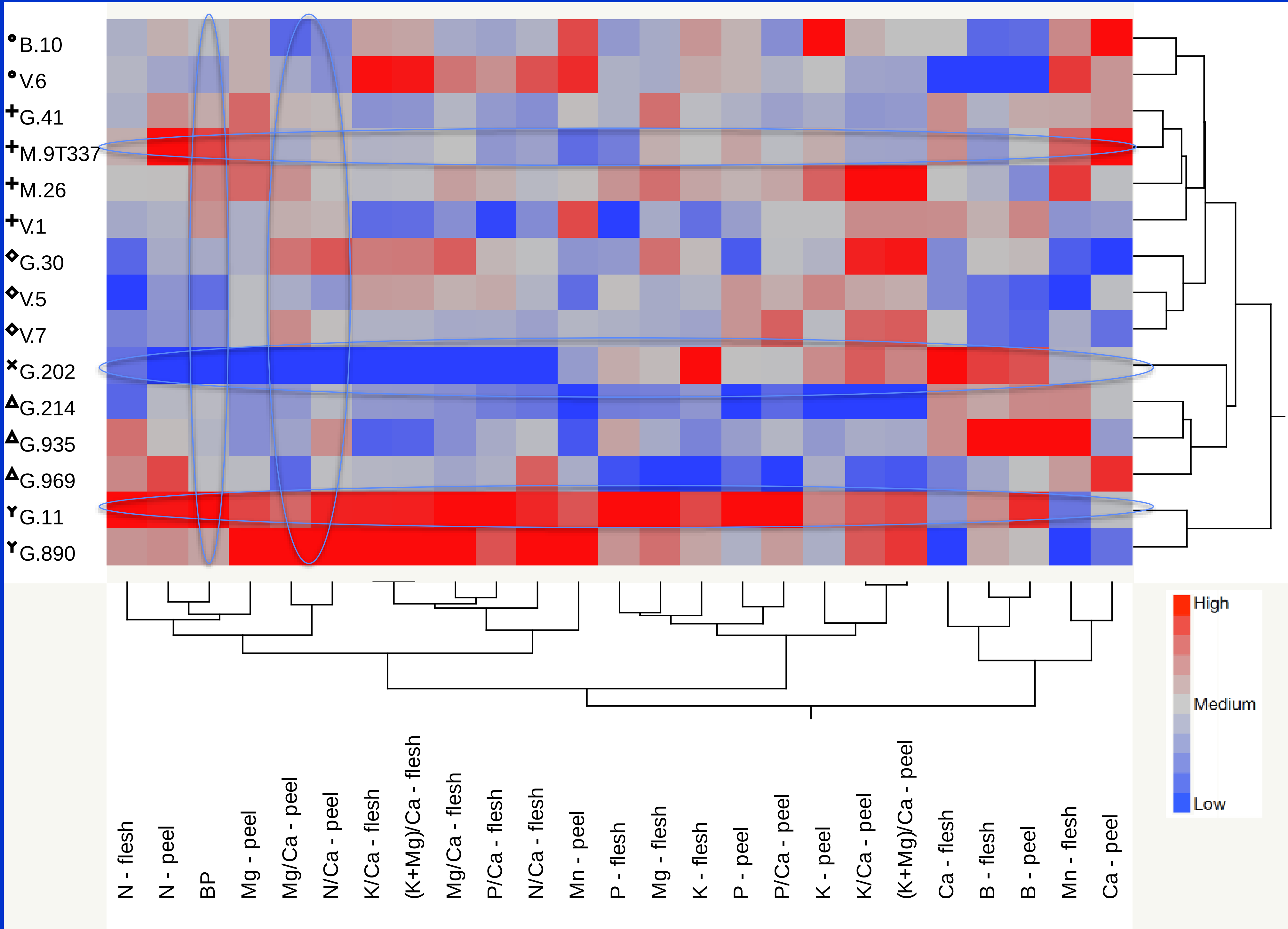


Honeycrisp 4th leaf



G.210

- Vigor similar to M.7
- Precocious, productive
- Yield efficiency similar or better than M.9
- Resistant to apple replant disease.
- Resistance to woolly apple aphid, fire blight, and crown rot.
- Good rooting in stoolbed few spines.
- Great for Organic Production


B.10
V.6
G.41
M.9T337
M.26
V.1
G.30
V.5
V.7
G.202
G.214
G.935
G.969
G.11
G.890
N - flesh
N - peel
BP
Mg - peel
Mg/Ca - peel
N/Ca - peel
K/Ca - flesh
(K+Mg)/Ca - flesh
Mg/Ca - flesh
P/Ca - flesh
N/Ca - flesh
Mn - peel
P - flesh
Mg - flesh
K - flesh
P - peel
P/Ca - peel
K - peel
K/Ca - peel
(K+Mg)/Ca - peel
Ca - flesh
B - flesh
B - peel
Mn - flesh
Ca - peel
High
Medium
Low

Conclusions

- **Rootstocks not only affect tree size, yield efficiency and fruit size but also branch angle, return bloom, biennial bearing, mineral nutrient profile and bitter pit.**

- **Nutrient profiles were very different among rootstocks.**

- **This leads to the goal of “designer rootstocks” which combine the rootstock characteristics needed to maximize the potential of each scion cultivar in a particular climate.**

The right rootstock will result in high early yields will pay back the initial investment by the end of year 5

NY Targets for Early Yield

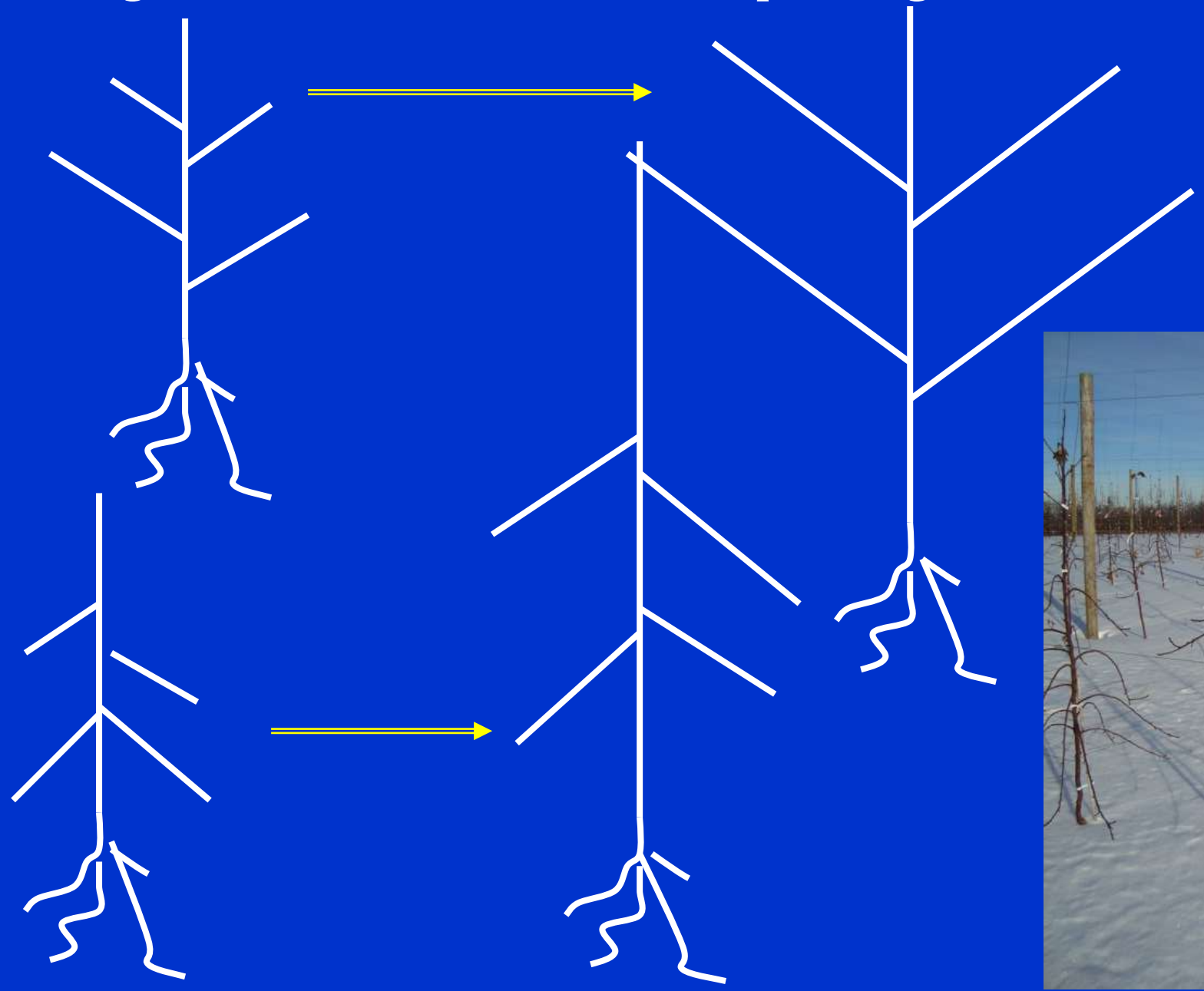
- 300 bu/ac in the second leaf
- 600 bu/ac in the third leaf
- 1,000 bu/ac in the fourth leaf
- 1,400 bu/ac in the fifth leaf

A total of 3,300 bu/ac over the first 5 years

Strategies for Early Fruit Production

-No Pruning at Planting (except the removal of large feathers)

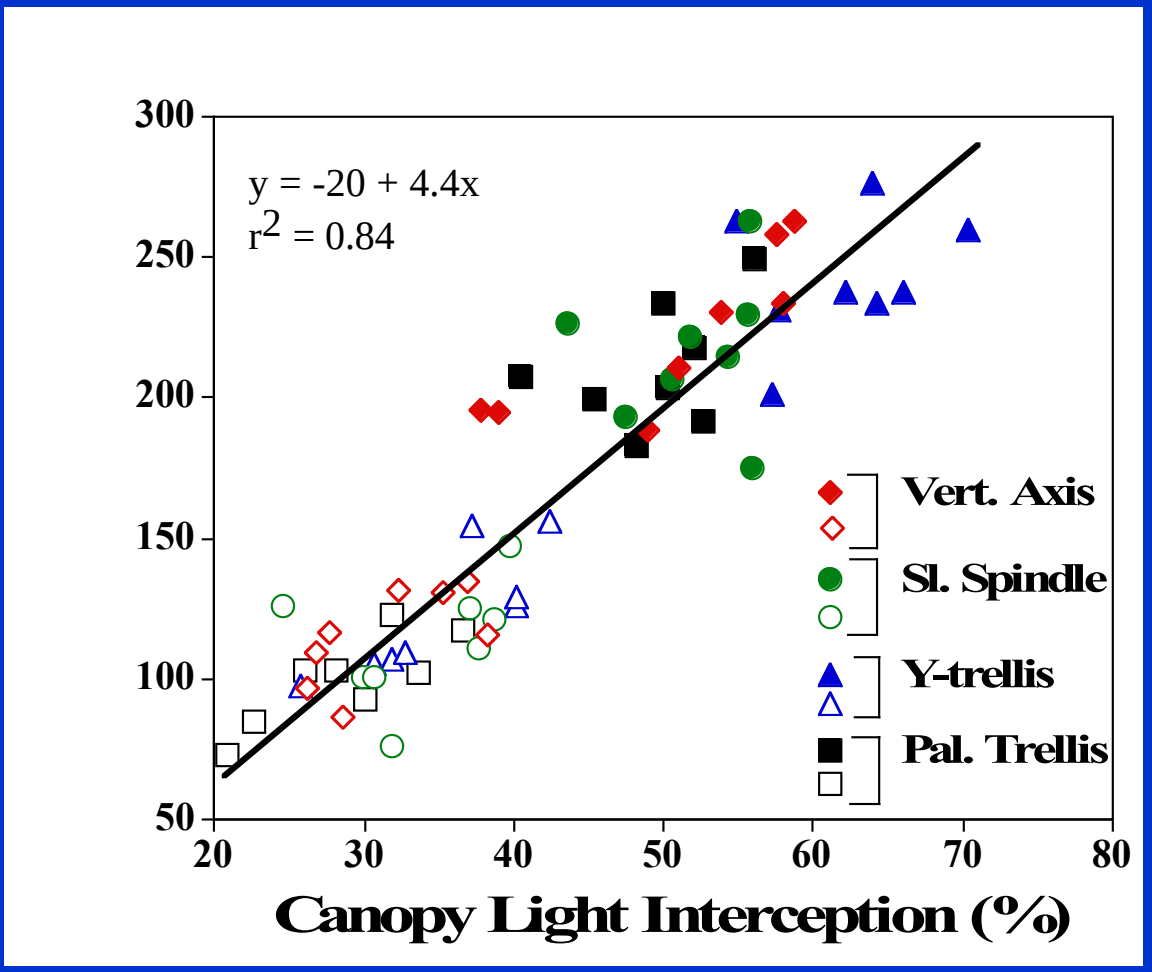
-Limb bending below horizontal soon after planting



Maximize Early Yield While not Reducing Later Yields Due to Poor Tree Growth

- Fill space by the end of the second year
  - Excellent soil Preparation
  - High Quality Trees
  - Early Spring or Fall Planting
  - Intensive Irrigation
  - Intensive Fertility
  - Excellent Weed Control
- Manage crop load in years 2-4 to 5 fruits/cm^2 TCA for Gala and 4 fruits/cm^2 for Honeycrisp

Tall narrow canopies will have higher yields (1,500-2,000 bu/acre)



70-75% Light Interception is Optimum

Pedestrian Orchards have moderate light interception and moderate yields unless row spacing is 7-8 ft.

Taller Trees intercept more light and have higher yields.

Tree Height=Between Row Spacing * 01.0-1.2 give 75% light interception

Higher fruit quality can be achieved with narrow canopies +

- Good Light Distribution in the Canopy
  - Sufficient light penetrates only 1m into the canopy
  - Narrow canopies produce the best fruit quality
- Hail Nets
  - Crop Insurance does not fully compensate the loss of high value varieties
- Shade Cloth
  - Reduces sunburn
- Reflective Film
  - Increases fruit color

Simple and Thin Canopies are More Adaptable to Partial Mechanization Than Thick Complex Canopies

- Pruning
- Hand Thinning
- Tree Training
- Trellis Construction
- Pheromone Dispensing
- Summer Pruning
- Harvest

The simple pruning recipe of the Tall Spindle is well adapted to the use of motorized platforms to reduce pruning costs

- The best fruit growers in NY have reported reductions in dormant pruning labor of 25-40% if the trees are grown in the Tall Spindle system.

Simple and Inexpensive Platforms

$25,000

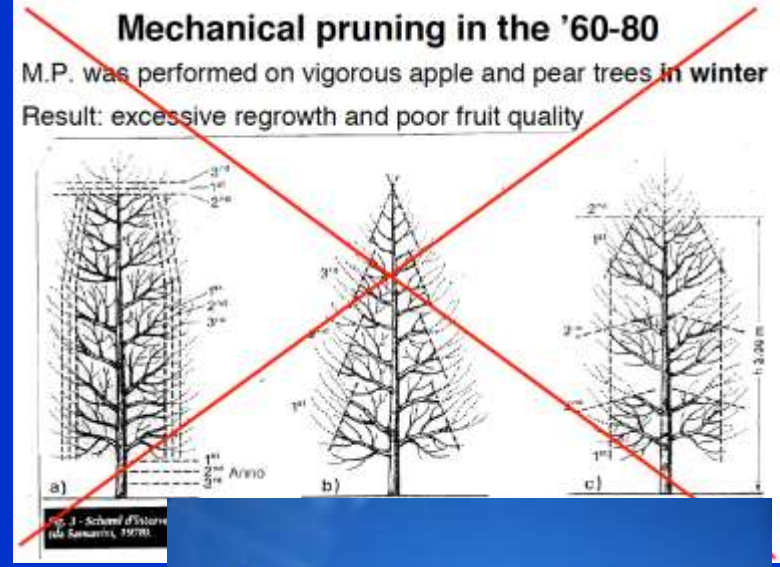
$12,500

The Wafler and Vandewalle Experience

Previous Hand Pruning for Gala = 40 hours/acre X $10/hour = $400 per acre
With Simple Platforms =18 hours per acre X $10/hour = $180/acre
Savings per acre = $220/acre

Mechanical Summer Pruning to Reduce Labor Cost

- Disastrous results in the 1960's and '70s
- What is different now
  - Orchards are more suitable
  - Dwarfing rootstocks
  - Calm trees
  - Small pendant fruiting branches
- Summer pruning timing
  - Less regrowth
  - Flower buds on end of regrowth
- High labor costs are pushing labor savings approaches



Mechanization of Pruning in Summer

NY Summer Shearing Studies

	Shoot Regrowth (cm)		
Variety	June	July	August
Fuji/M.9	18.4	18.6	13.8
Golden/M.9	8.8	14.1	12.9
Jonagold/M.9	12.8	16.0	15.2
Gala/M.9	8.7	12.3	11.3
Average	12.2 b	15.2 a	13.3 ab

	Flower Clusters per Cut		
Variety	June	July	August
Fuji/M.9	2.8	2.5	1.7
Golden/M.9	2.8	2.4	1.8
Jonagold/M.9	2.5	2.0	2.2
Gala/M.9	1.5	1.4	1.4
Average	2.4 a	2.1 b	1.8 c

Strategy for Summer Hedging

1. Begin in year 5 with a hedging treatment in dormant season to define the “box”
2. Follow with a good dormant pruning leaving only small branches.
3. Use mechanized summer hedging in the summer (late June) then
4. A corrective dormant pruning each year to remove limbs that have become too large and remove small weak wood to manage flower bud load.

Harvest Mechanization

Harvest labor represents 1/3 of the annual labor costs

Harvest labor is becoming increasingly more expensive and less available

Also ladders are a liability

Harvest Assist Machines Offer Greater Opportunities

-Motorized platforms can improve harvest labor efficiency of the Tall Spindle by 15-25%.

European Platforms have not been adopted in the US

1. Picking rates are already higher in the US (5-8 bins per day) than many other places in the world (3 bins/day)
2. The increase in efficiency has been small (20%) compared to the cost of the machine ($100k).
3. The bin fillers are believed to cause some bruising.

Bandit Express Machine

Inexpensive ~$60,000

Harvest only the tops with a separate ground crew harvesting the bottoms

The Wafler Harvest Assist Machine

Positions the bins close to the worker in an innovative slanted system to eliminate the inefficiencies of climbing ladders and walking to the bin

- A crew of 8 pickers works on and operates the machine
- They harvest all levels of the tree at same time

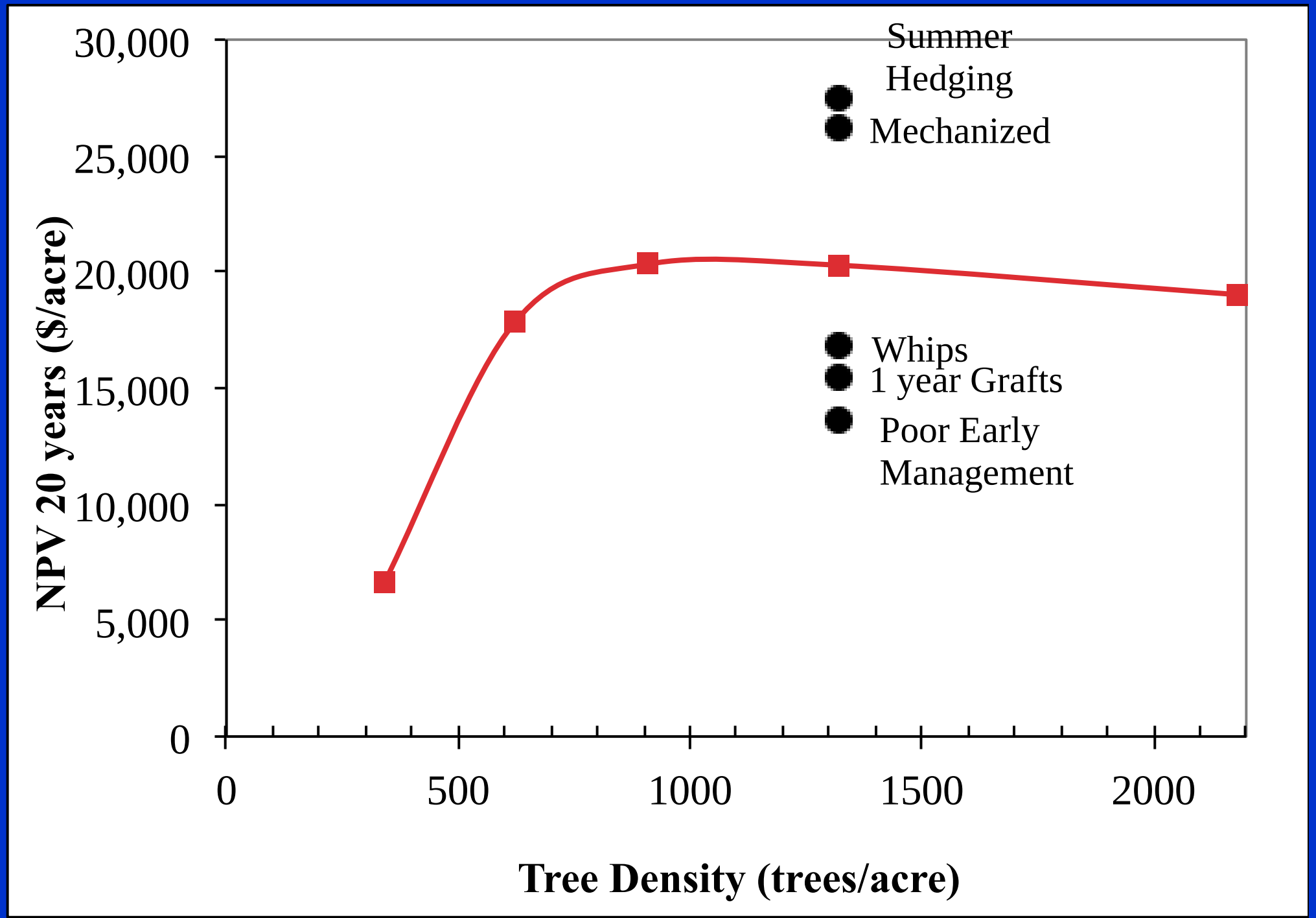
Estimates of harvest assist machine performance, cost per bin and labor savings per bin

Machine	Number of Pickers	Bins per Day	Acres/ Season	Bins/ Season	Cost of Machine	Cost/bin harvested	Labor Savings/bin	
Human w Ladder	1	6	4.8	288	~$12.5	$ 0.04	$0	
Platforms (Blosi)	4	32	51	1536	~$60,000	$ 3.90	$9	
Picker Tec	4	32	26	1536	~$250,000	$16.27	$9	
Argiles	8	64	51	2448	~$125,000	$ 5.10	$9	
Pluck-O-Trac	6	48	38	2304	~$80,000	$ 3.47	$9	
Imperador(Brazil)	4	32	51	1536	~$40,000	$ 2.60	$9	
Bandit Xpress	4	32	51	2448	~$60,000	$ 2.45	$9	
Wafler	8	64	51	2448	~$60,000	$ 2.45	$9	3.8yrs

The possibility of reducing labor costs by combining the Tall Spindle system with partial mechanization

Labor Inputs	Traditional VA Trees (1000 bu/ac with ladders)	Tall Spindle Trees (1500 bu/ac with machines)
Dormant Pruning	50 hours/acre	20 hours/acre
Tree Training	10 hours/acre	10 hours/acre
Hand Thinning	60 hours/acre	30 hours/acre
Summer Pruning	40 hours/acre	1 hour/acre
Total Pre-harvest	160 hours/acre	61 hours/acre
Harvest	75 hours/acre (6 bins/person/day)	70 hours/acre (10 bins/person/day)
Total annual labor input =	235 hours/acre	131 hours/acre

Partial Mechanization can Significantly Improve Profitability



What will the orchard of the future look like?

- Orchards will have high yields in the first 5 years (3,300 bu) using feathered trees.
- Orchards will have thin, narrow canopies which will have high yields and uniform fruit quality and will be more adaptable to harvest and pruning assist machines.
- Orchards will have more uniform fruit quality through precision orchard management.
- Orchards will have densities between 1,000-1,400 trees/acre

Robot-ready orchard designs that have planar (2D) orchard designs

What should you take home

- Plant new orchards only with high priced varieties
- Plant ~1300 trees/acre
- Select a rootstock that will fill the space in 2-3 years and that will have high cumulative yield
- Mechanize pruning, hand thinning and harvest
- Invest in technology that improve fruit quality (sunburn and color)
- There are still great opportunities growing apples.


Thank you for your attention
Read our research results in the New York Fruit Quarterly
http://www.nyshs.org/fq.php