Cornell Fruit School: Precision Crop Load Management and Plant Growth Regulator Use in Apple

Precision Pruning and Thinning in Washington

Stefano Musacchi and Tory Schmidt

WSU TREE FRUIT ENDOWMENT

Syracuse NY
March 26TH, 2019

WASHINGTON TREE FRUIT RESEARCH COMMISSION

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Crop load and Quality

- **Crop load is a key cultural component of final fruit quality.**
- **Crop manipulation and effects of harvest time and fruit maturity are of particular importance to growers** enhancing the proportion of the crop achieving desired qualities.

Fruit Attributes

- Crop load has a number of consequences in terms of quality attributes of fruit.
- Light crop loads provide fruit that have advanced maturity.
- There is a conflict in matching a desire to optimize cropping and at-harvest qualities with orchard practices that are best for optimal storage behavior of the fruit.

HC crop load trial: fruit quality at T0 (1 month after harvest)

Table 2. Effect of crop load on measures of fruit quality and maturity shortly after harvest (1 month of storage at 1 °C), and differences in measures of fruit quality and maturity according the I_{AD} classification for 'Honeycrisp' apple fruit grown in the northwestern United States.

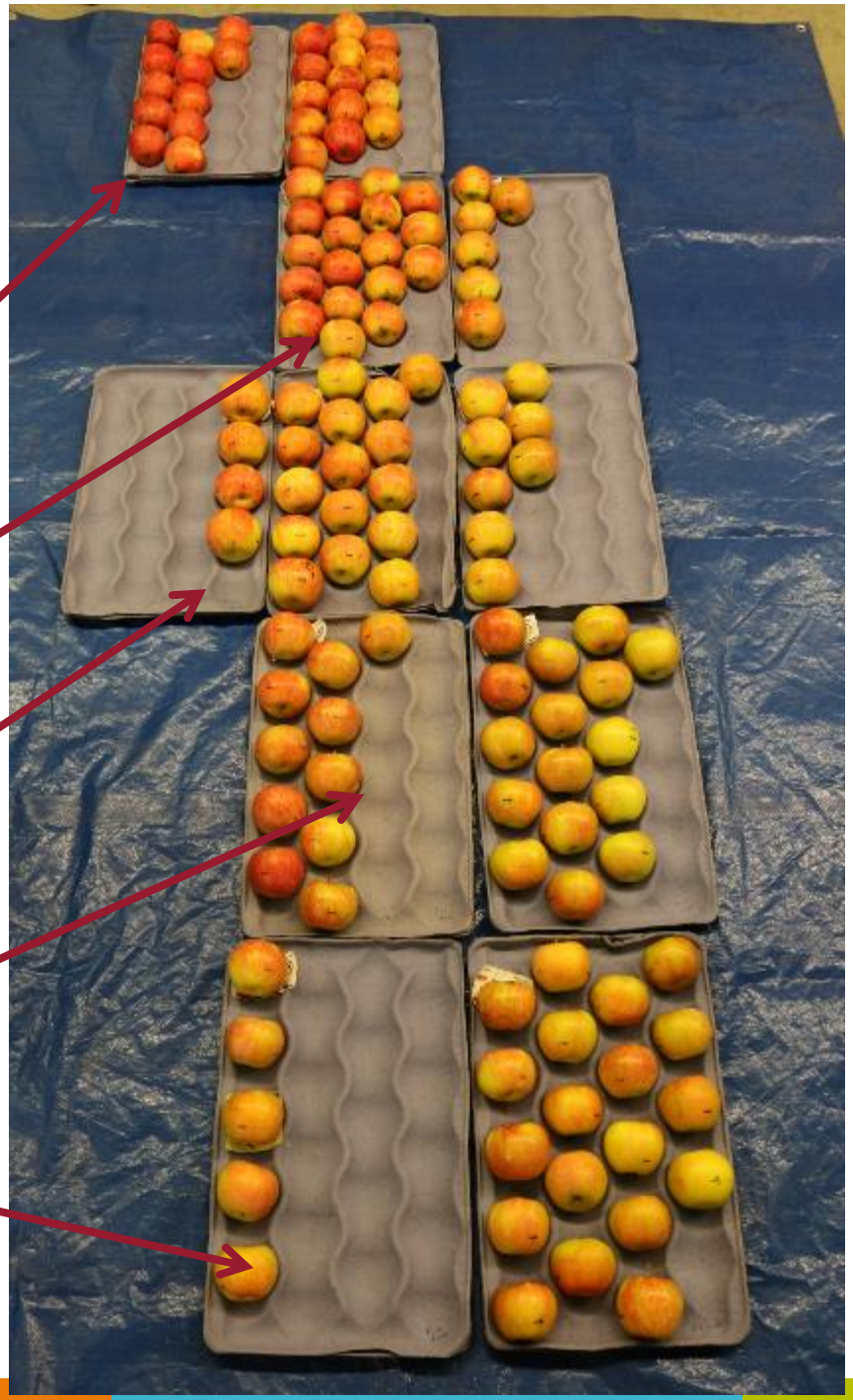
Crop load (no. fruit/cm² TCSA)	I_{AD} range	Wt (g)	I_{AD} (T0)	Color parameters: Red-blushed surface (overcolor) (%)	Color parameters: Overcolor ($h°$)	Color parameters: Overcolor (chroma)	Color parameters: Background ($h°$)	Color parameters: Background (chroma)	Starch (1–6)	IEC (µmol)[z]	pH[y]
4.7		191.7 a	0.65 c	71 a	33.5 c	43.5 a	102.3 b	45.9 a	4.0 –	0.5 b	3.34 –
7.5		185.4 ab	0.84 b	66 a	39.8 c	38.6 b	101.5 b	42.1 b	4.2 –	1.1 a	3.32 –
11.3		175.6 bc	0.85 b	53 b	54.6 b	35.2 c	106.5 a	44.0 ab	4.6 –	0.2 b	3.34 –
12.5		174.4 bc	0.96 ab	54 b	55.9 b	35.0 c	107.8 a	44.7 a	4.6 –	0.2 b	3.32 –
16.0		168.5 c	1.10 a	40 c	66.1 a	33.7 c	109.1 a	45.4 a	4.2 –	0.0 b	3.35 –
Significance[x,w]		***	***	***	***	***	****	***	NS	***	NS
	<0.60	176.3	0.4 c	79.8 a	29.4 c	45.4 a	99.3 c	42.7 b	4.8 a	0.6 a	3.35 a
	0.60–0.99	181.8	0.8 b	60.7 b	44.3 b	37.8 b	104.9 b	44.0 b	4.6 b	0.5 ab	3.34 b
	>1.00	177.9	1.1 a	44.9 c	63.6 a	33.7 c	108.2 a	45.6 a	3.8 c	0.2 c	3.31 c
Significance[x]		*	***	***	***	***	***	***	***	*	***

Crop load → **4.7 fruit/cm²** **16.0 fruit/cm²**

HortScience 51(3):1–9. 2016.

Crop Load Influences Fruit Quality, Nutritional Balance, and Return Bloom in 'Honeycrisp' Apple

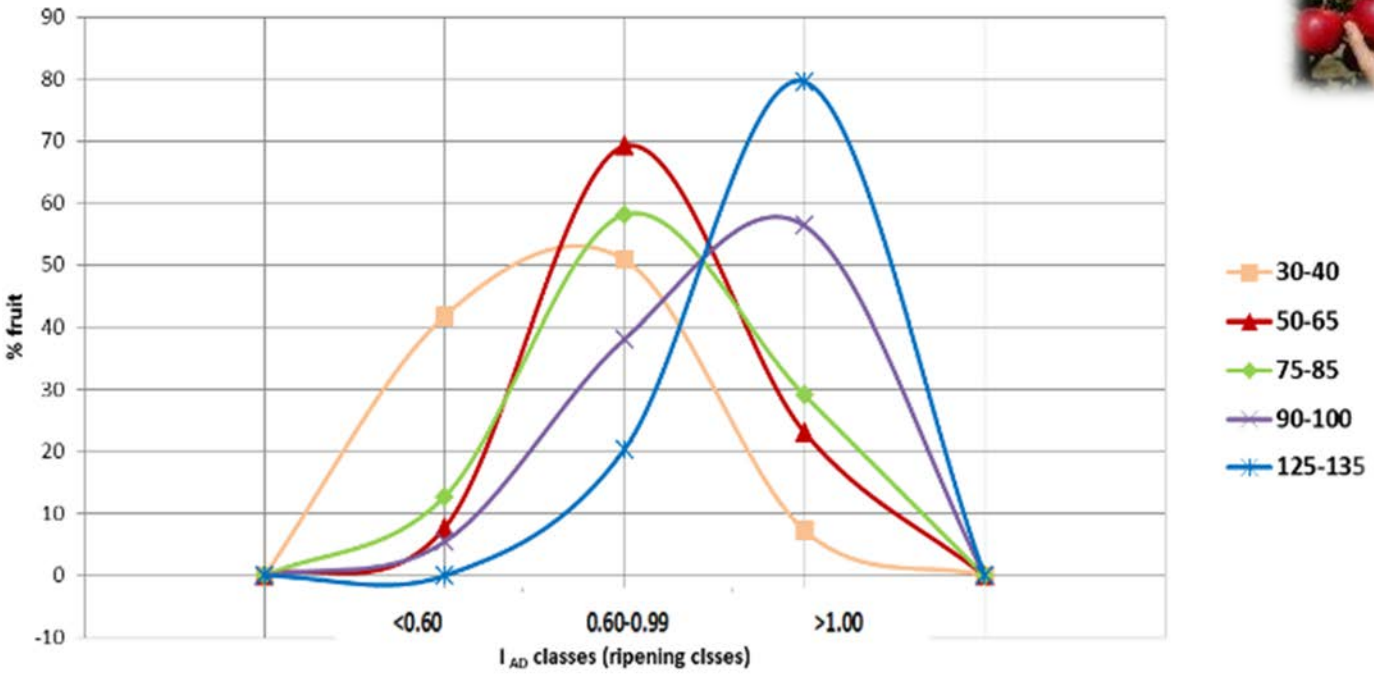
Crop load
30-40
50-65
75-85
90-100
125-135



HortScience 51(3):1–9. 2016.

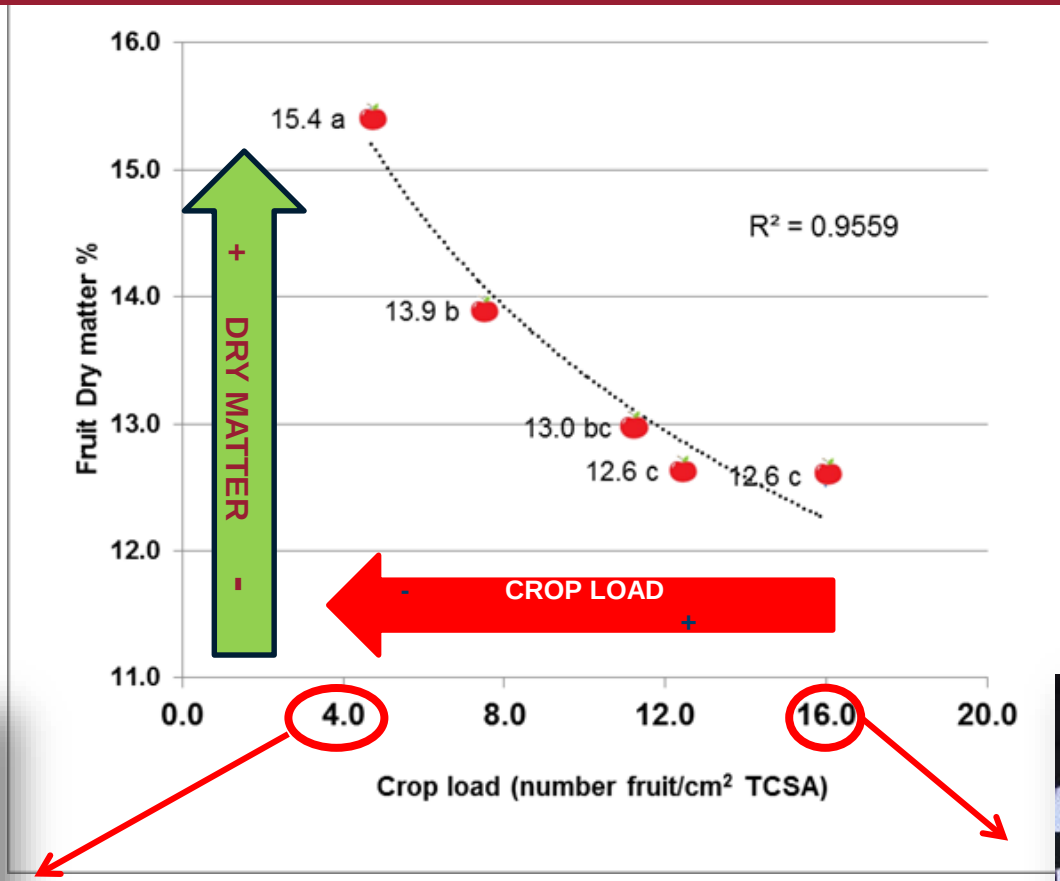
Crop Load Influences Fruit Quality, Nutritional Balance, and Return Bloom in 'Honeycrisp' Apple

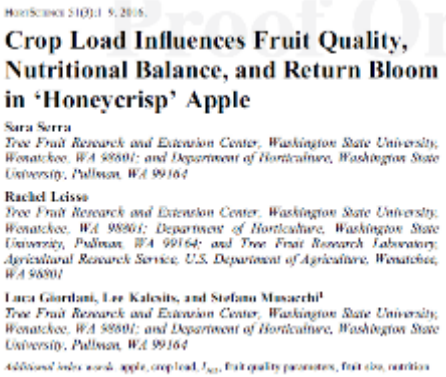
Fruit distribution in I_{AD} classes: comparison between different crop loads (at T0=1 month after harvest)



Higher the fruit Dry Matter (DM), greater the consumer acceptability. DM suggested as a fruit final quality predictor

(Palmer et al., 2010).





HortScience 51(1):1–9. 2016.

Crop Load Influences Fruit Quality, Nutritional Balance, and Return Bloom in 'Honeycrisp' Apple

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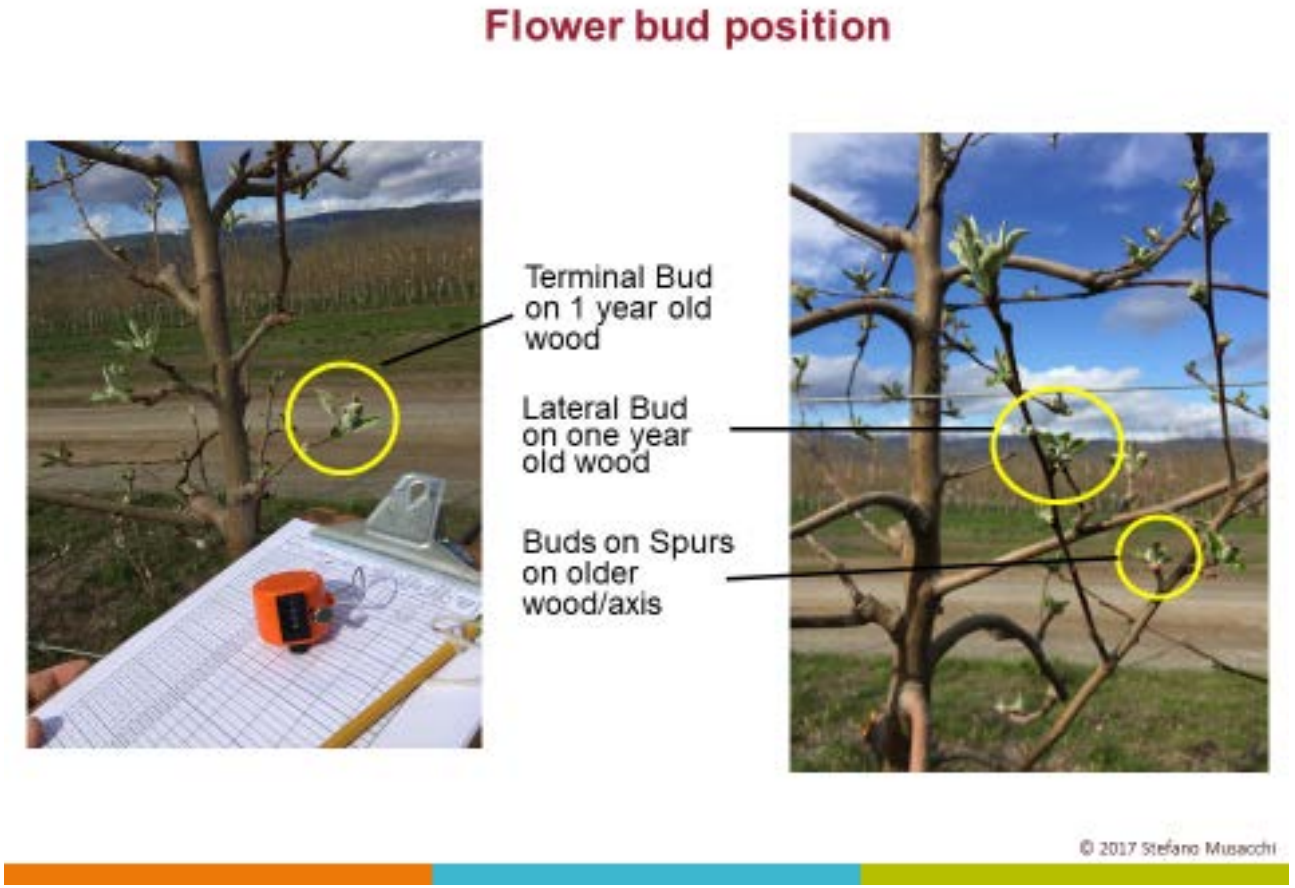
Fruit Growth

Since apple fruit are a major sink for carbon resources, the rate of fruit growth depends primarily on crop load but also on **flowering time** and **flower position** on the tree and within the spur.



Fruit size

- **Fruit weight at harvest is typically negatively correlated with crop load**, and fruit weight is largest when there is minimum fruit to fruit competition, i.e., high leaf area per fruit ratio (Shen 1941; Hansen 1969; Palmer et al. 1997).
- **Flower thinning of 'Braeburn' trees at different severities resulted in 50% heavier fruit in the low cropping trees compared to the high cropping trees** (Wünsche and Palmer 1997; Wünsche et al. 2000).
- Thinning trials done by Link (2000) indicated that **mean fruit size was increased by up to 30% when crop densities were established between pink bud and full bloom** when compared to after "June" drop (Northern hemisphere).
- **Blossom thinning increased cell number by 5–35% and cell size by 4–10%** when compared to unthinned controls.

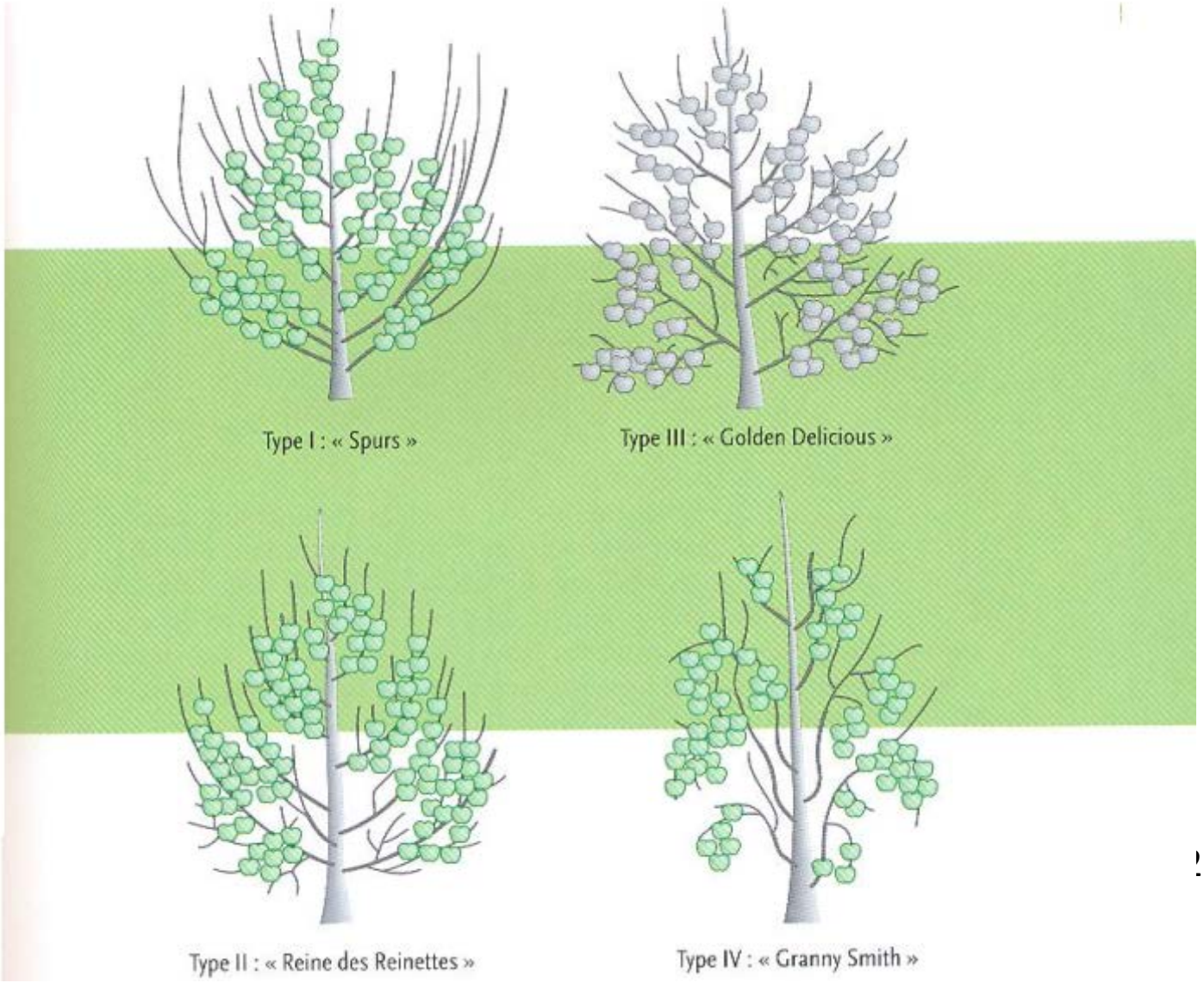
At-harvest Quality

- The **relatively high soluble carbohydrate content of fruit from light cropping trees** may be a **positive factor in terms of consumer acceptance of fruit.**
- **Fruit well supplied with carbohydrates attain good color and flavor** (Walter 1967).
- In accordance with this, **thinning to lower fruit loads reduces the percentage of under-colored** fruit by increasing background color and surface blush (Link 2000).
- The improvements in **fruit size and color by thinning are often associated with higher contents of soluble solids and titratable acidity.**
- **Thinning may therefore improve taste and appearance of the fruit** (Schumacher and Stadler 1987).

A) PRECISION PRUNING

- Cultivar *Habit*
- Color of the skin
- Tree quality from Nursery
- Training system
- Precision shoot formation
- Targeting a crop load

Apple habit



Lespinasse, 1980

Type I – ‘Red Delicious’ spur Types

- Cultivars that belong to this group have a **strong tendency to develop branches at the bottom of the tree (basitony).**
- The dominance of the trunk (leader) is not particularly strong and varies among cultivars. **The majority of the fruiting spurs are located on branches that are at least 2 years old**. The fruit remain close to the main branches, so the fruit set area is close to the main structure of the tree.
- The natural tendency of these cultivars is to **produce short nodes with many flower buds**.
- The **leaves are highly photosynthetically efficient** and present a strong tendency to produce a crop in a biennial way.
- **Accurate thinning and bud removal is important with an emphasis on removing the flower buds** located on the bottom part of the branch or that exhibit a small size (Sansavini and Corelli, 1990).

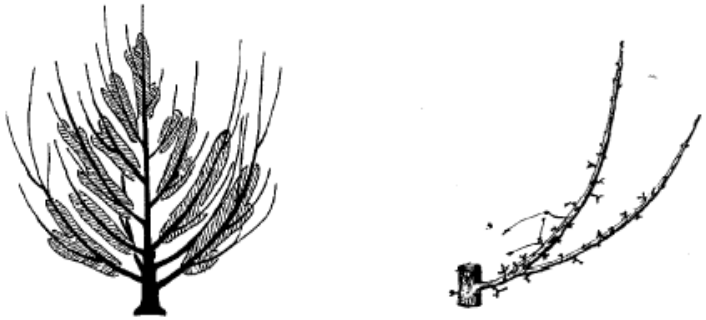


Fig. 3.10- Fruiting habitus type I (modified from Lespinasse, 1980).

Spur type= Starkrimson

Type II - cv 'Red Delicious', 'Reine des Reinettes', 'Stayman', and 'Gloster'

- These cultivars are **easy to manage in the free-growing form.**
- The main **branches** are inserted to the trunk **have strong wide angles.**
- These **trees normally show greater dominance** of the central leader than the spur-types.
- However, **basitonic tendencies remain strong particularly on vigorous rootstocks**.
- The majority of the **fruiting spurs are located on branches that are 2 to 4 years old.**
- **Crowned brindles occur more frequently than in spur-types and require the bending of the shoots and branches** to encourage flowering and fruit set (Sansavini and Corelli, 1990).

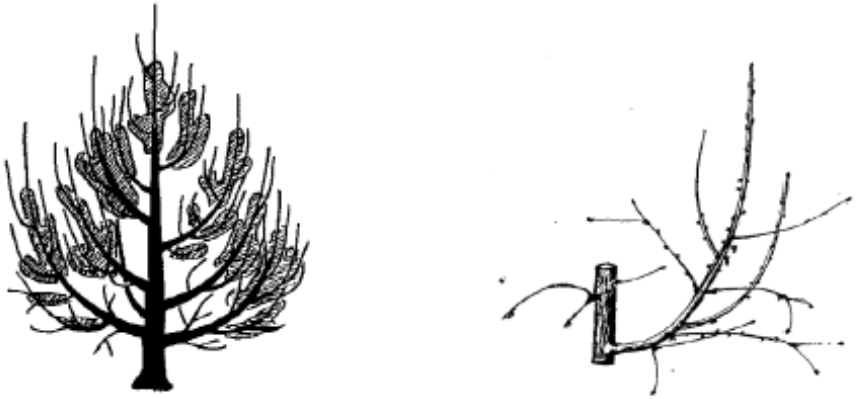


Fig. 3.11- Fruiting habitus type II (modified from Lespinasse, 1980).

Red Delicious

Type III - cv ‘Golden Delicious’, ‘Gala’, ‘Braeburn’, and ‘Cripps Pink’ and Fuji

- Cultivars that belong to this group **are well-suited to be trained as “vertical axis” or spindle system with fruiting branches directly on the trunk with a wide angle (60-90°).**
- Fruiting spurs are principally situated on **young wood of 1 to 3 years.**
- There are numerous coronate twigs (short shoots).
- **The fruiting zone moves rapidly away from the center of the tree and causes the bending of branches**.
- Some of these cultivars, when over-cropped can **become biennial** (Sansavini and Corelli, 1990).

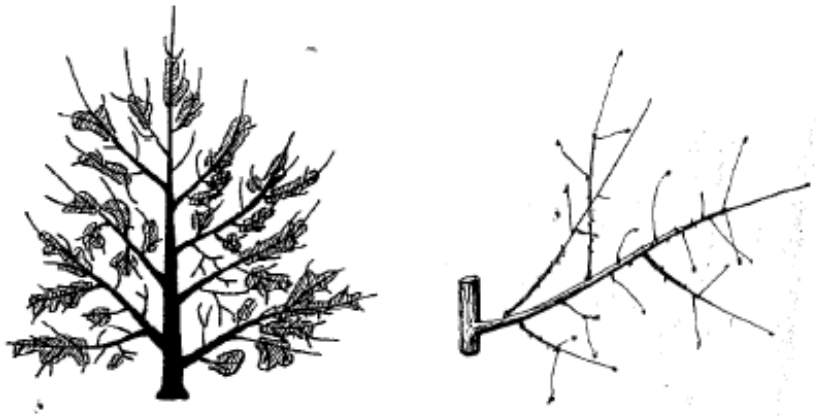


Fig. 3.13- Fruiting habitus type III (modified from Lespinasse, 1980).

Golden Delicious

Type IV - cv ‘Rome Beauty’, ‘Granny Smith’, Cortland, and WA38

- These cultivars **rarely develop lateral shoots in the lower portion of the trunk and branching** is located on the upper third of the trunk (leader), which gives the tree a cylindrical appearance (acrotonic tendency).
- Most of the fruiting spurs are located on young **wood of 1 or 2 years**.
- The **fruiting zone moves towards the outside of the tree**, especially in ‘Granny Smith’ and ‘WA38’ (Sansavini and Corelli, 1990).

Rome Beauty

Fig. 3.15- Fruiting habitus type III (modified from Lespinasse, 1980).

A) PRECISION PRUNING

- Cultivar *Habit*
- Color of the skin
- Tree quality from Nursery
- Training system
- Precision shoot formation
- Targeting a crop load

Different apple needs different training system

GOLDEN DELICIOUS

GRANNY SMITH

RED DELICIOUS

GALA (bicolor)

Fruit exposure to the light and effect of leaves shadow

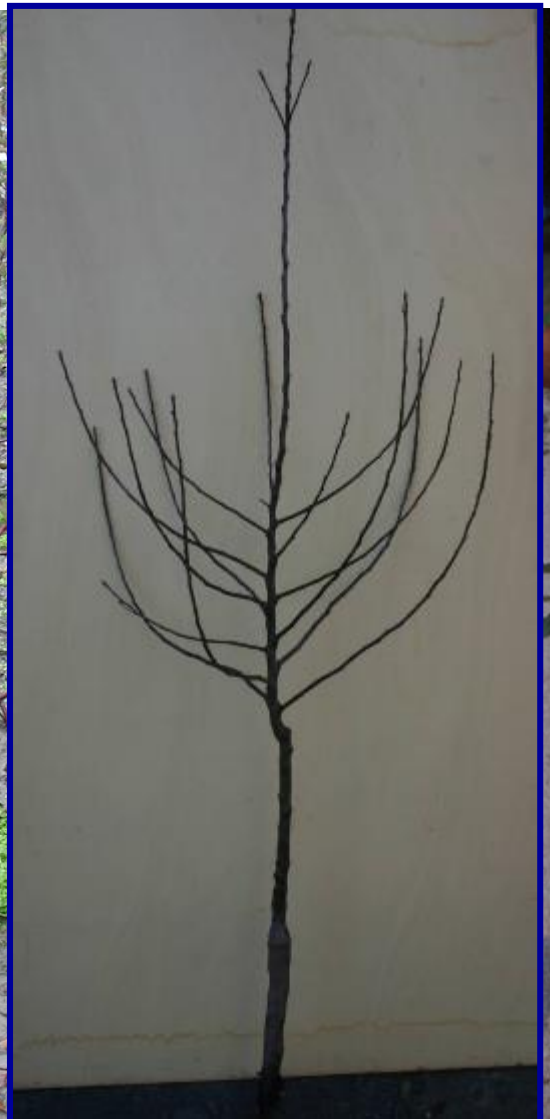
A) PRECISION PRUNING

- Cultivar *Habit*
- Color of the skin
- Tree quality from Nursery
- Training system
- Precision shoot formation
- Targeting a crop load

Different kind of tree produced in the nursery

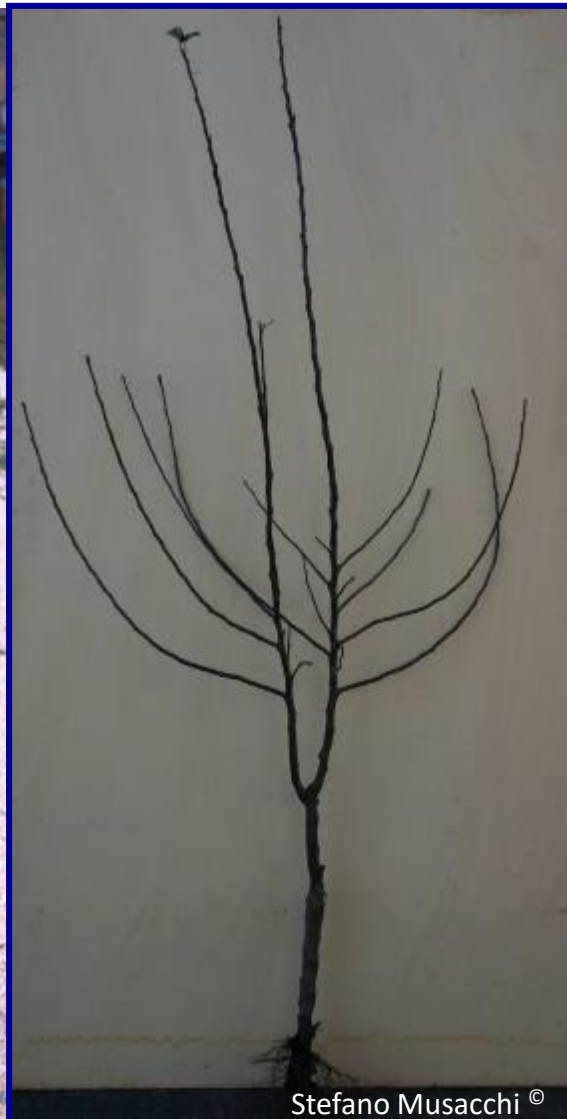
Biennial cycle

Knip



Short cycle (1-yr-old)

BIBAUM ®



A) PRECISION PRUNING

- Cultivar *Habit*
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Canopy shape Spindle, Bi-axis and V-system

WSU TREE FRUIT ENDOWMENT

Solaxe

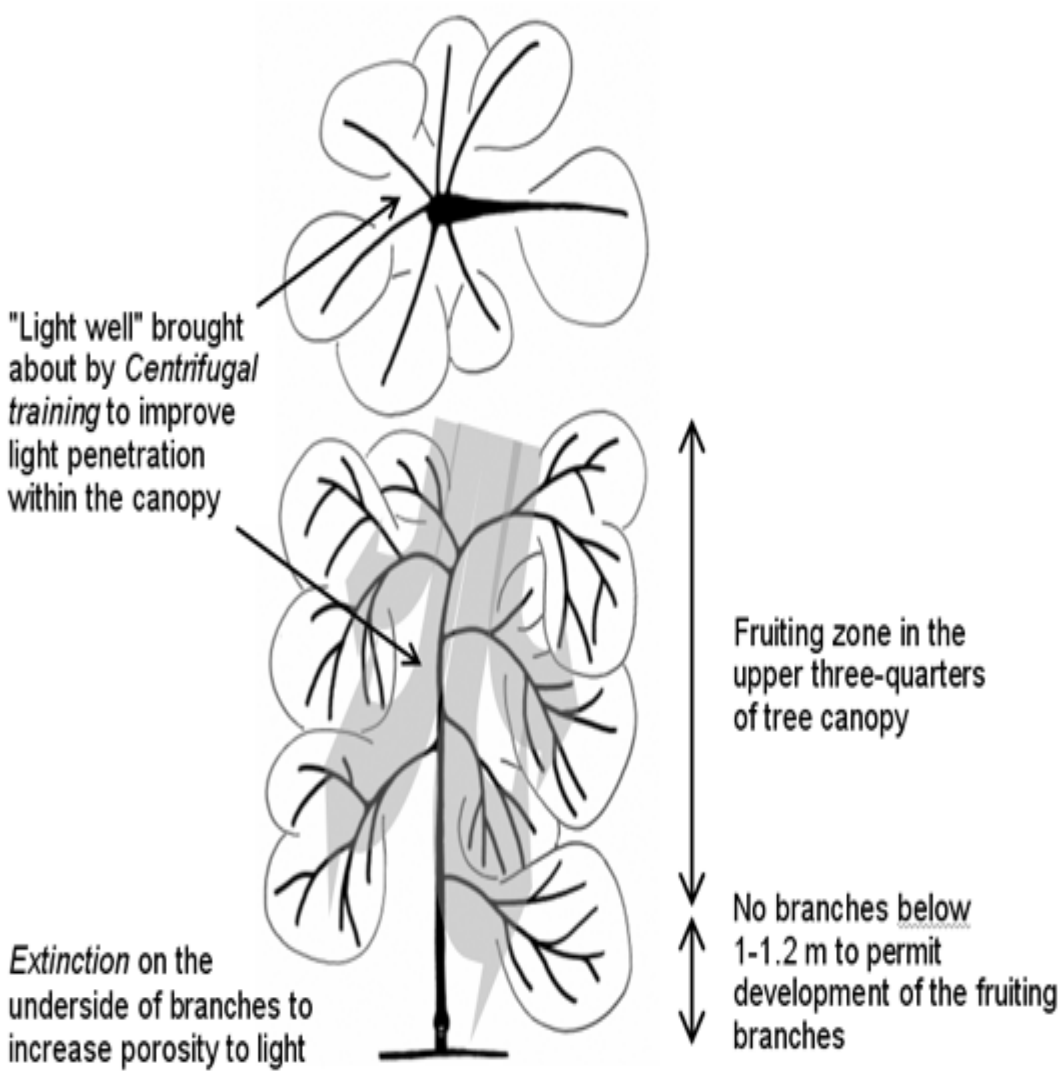
The solaxe is the combination of two training systems; the “Solen” (Lespinasse, 1989) and the “Axe vertical” (Lauri and Lespinasse, 2000).

This training system is based on the progressive **formation of the tree structure, to establish an equilibrium between vegetative and fruiting** activity.

This situation can be obtained with the use of **permanent fruiting branches.**

Central axis and the fruiting branches grow freely, whereas competing vegetative shoots are removed.

As the branch ages, secondary fruiting formations like brindles and fruiting spurs will develop.



Bending and long pruning 1

- Bending is the basis of the pruning technique developed by Jean Marie Lespinasse and the Mafcot ("Maitrise de la fructification, concepts et techniques") research group.
- The **fruit bearing units are reduced by the application of “extinction” technique (flower buds removal) to lower their density and optimize light exposure** (Diemoz, 2005).
- Lespinasse and Delort (1986) state the essential principles to control fruiting with long pruning are:

1. development of branches **high on the main trunk,**
2. **all the feathers below 1m are removed** to prevent branches touching the ground under fruit weight,
3. **branches are bent to increase flower bud formation** in the middle-upper part of the tree.

Bending and long pruning 2

The Mafcot research group developed an instrument called “**l'Equili-fruit®**” that determines **the number of fruiting units that should be retained on a branch.**

This gauge-like instrument measures the diameter of each branch to determine the optimum number of flower buds to maintain for a correct productive bearing.

This manual procedure is performed during the first two years after planting and takes approximately **150 hours per hectare each year**; once the tree is formed, pruning time is reduced dramatically (Diemoz et al., 2002).

Bending and long pruning can also be utilized in a spindle tree to reduce vigor and increase flower bud formation.

V TRELLIS – ANGLE CANOPY

Bi-axis

New ideas regarding tree shape include plants with 2 or 3 axis so as to divide the vigor over more branches.

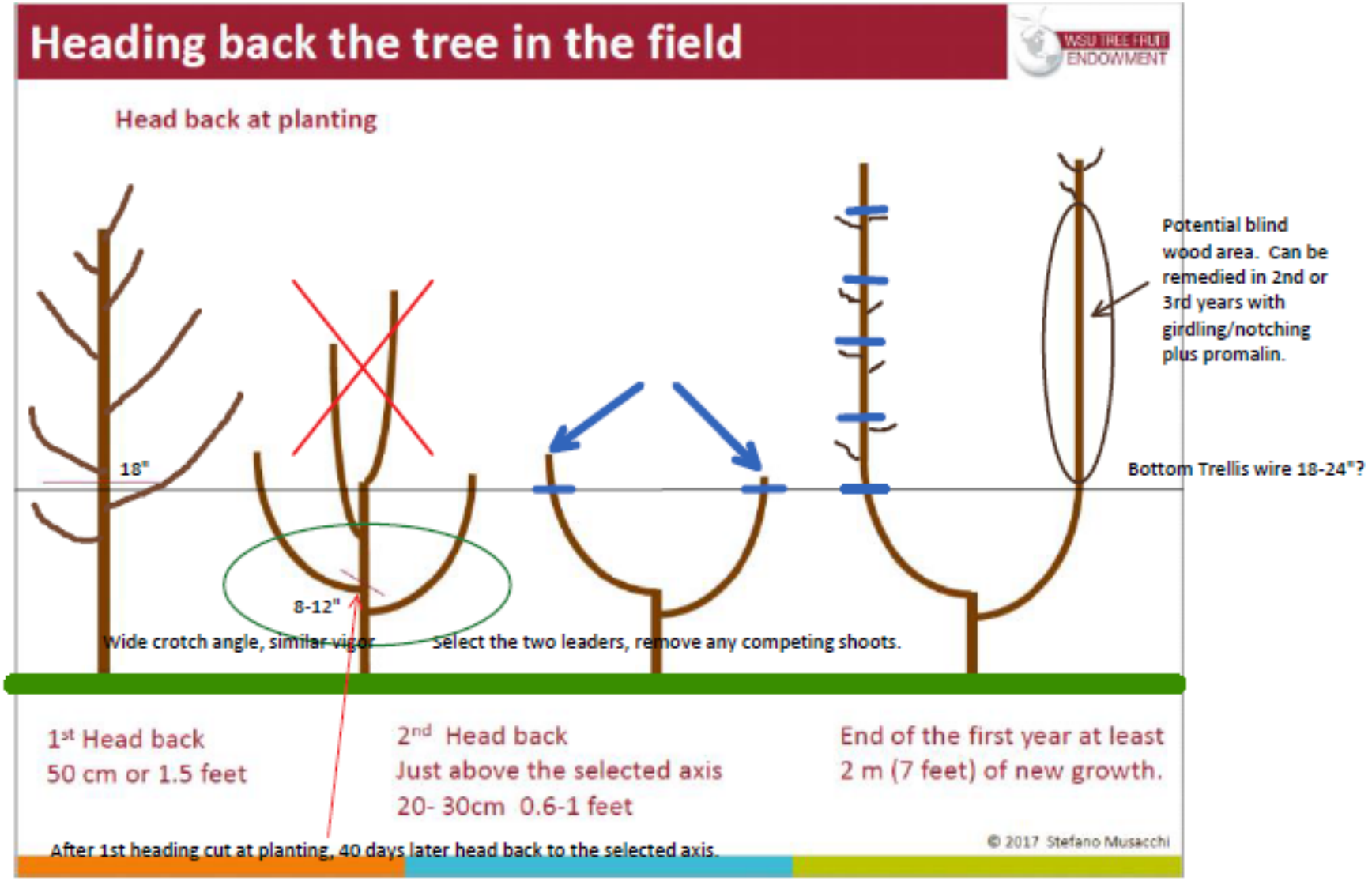
WSU TREE FRUIT ENDOWMENT

Bi-axis

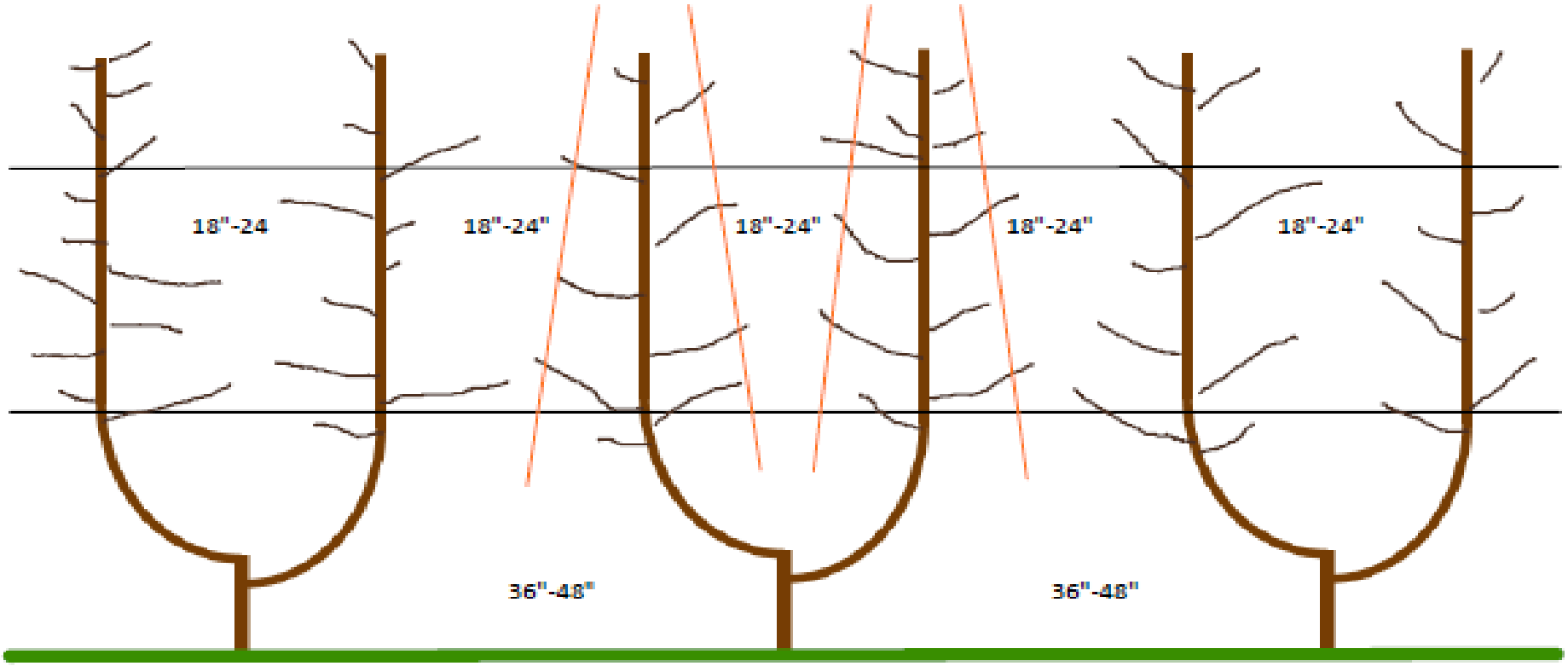
- Ideally, we need **20-25 small branches on each axis.**
- **It is not recommended to top the tree axis on apple.**

WSU TREE FRUIT ENDOWMENT

Bi-axis



Bi-axis

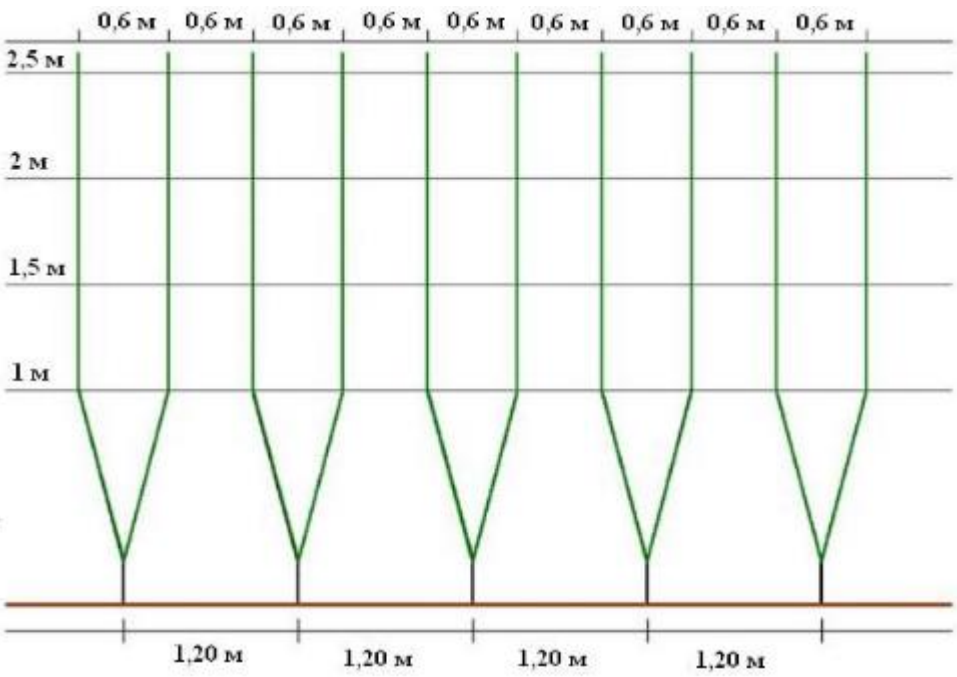


Orchards mechanizations

MECHANICAL PRUNING

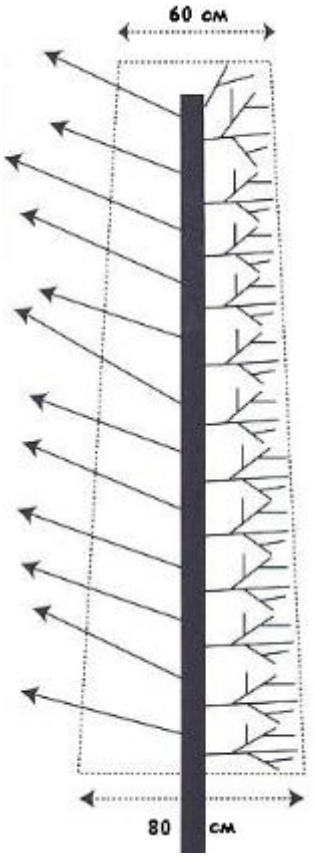
Flat canopy is the requirement for mechanical pruning

Bi-axis tree



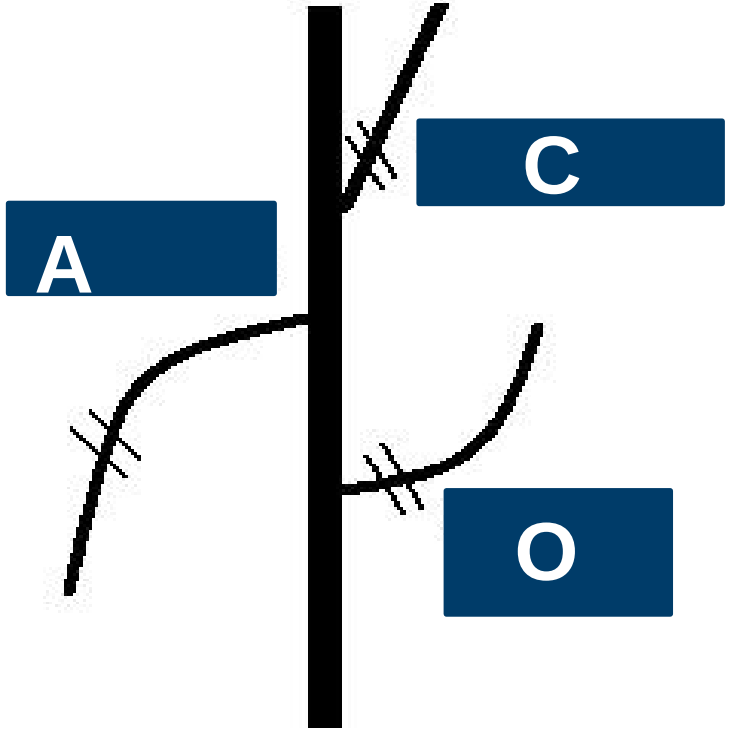
MUR FRUITIER PRUNING

Fruit wall? Concept of pruning



Pruning basis AOC - Winter pruning by hand

- A= Affaisses = Sagging
- O= Oublies = Forget
- C= Concurrents = Competitor



Pommier, le Mur fruitier, 2002
A. Masseron

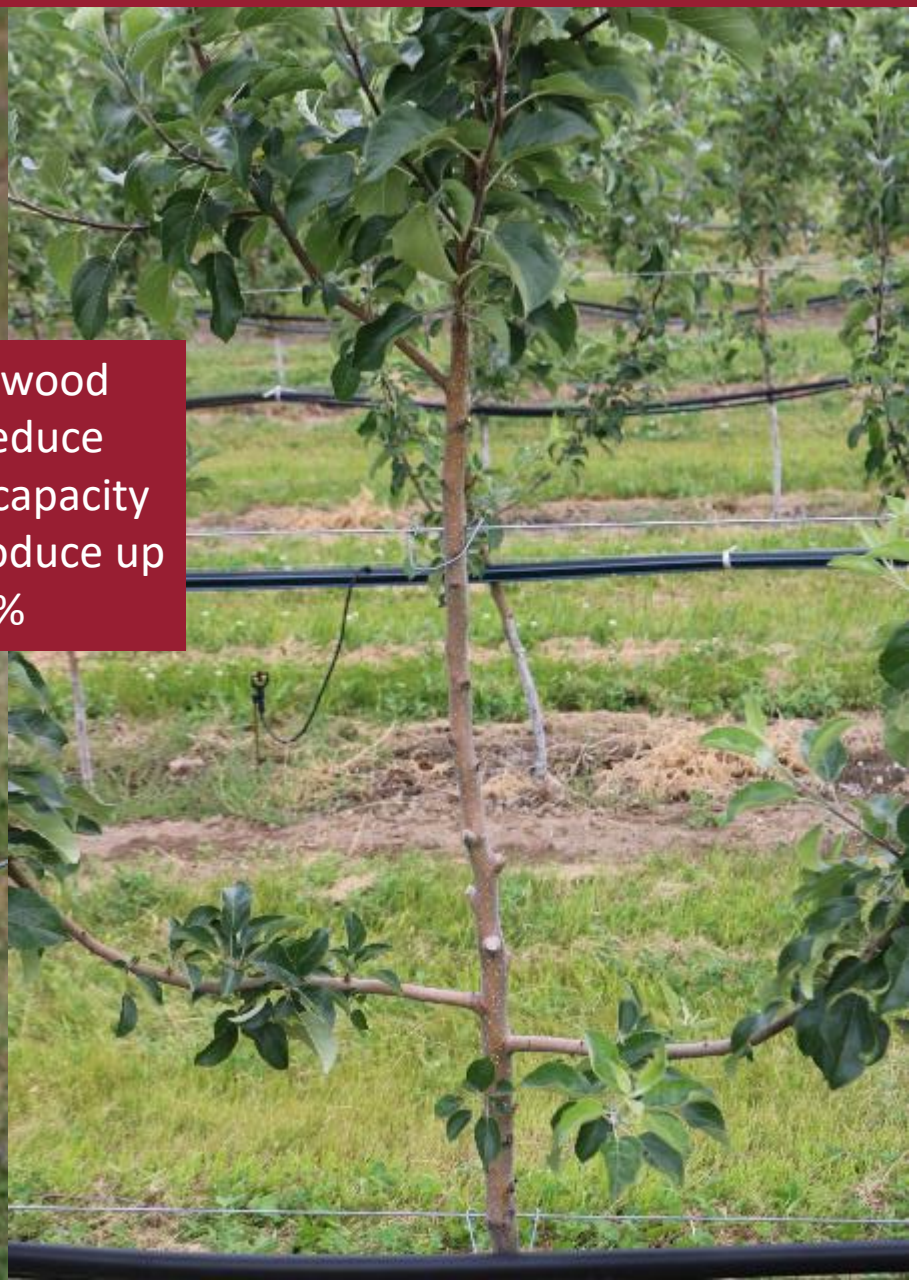
Fruit wall - Filling surface
13,000 to 17,000 m^2 of surface per ha (25 fruits/m^2) 400,000 fruit /ha (161,900 fruits/acre)

Effect of mechanical pruning on flower bud formation

A) PRECISION PRUNING

- Cultivar *Habit*
- Color of the skin
- Tree quality from Nursery
- Training system
- Precision shoot formation
- Targeting a crop load

Blind wood



Blind wood can reduce your capacity to produce up to 40%

Blind wood

Technique to enhance precision shoots formation and minimize blind wood

- Stub pruning (Dutch cut)
- Girdling and Scoring
- Growth regulators
- Click pruning

Dutch cut

- For training systems with vertical axes that have short fruiting shoots extending from the trunk, lack of shoot renewal or regrowth of a vigorous upright bud following an angled cut, can occur.
- This can be remedied using a so-called '**Dutch cut**' or cutting horizontally, instead of at an angle.
- **This often results in the growth of a bud from the lower side of the horizontal cut that develops at an appropriately wide angle from the trunk.**
- This pruning technique results in the formation of **two new shoots that are less vigorous than the initial shoot** and that are usually at a wider trunk insertion angle.
- Pruning is performed in **winter**.

Stub length can strongly effect new shoots growth

Flat cut made the wood blind

Technique to enhance precision shoots formation and minimize blind wood

- Stub pruning (Dutch cut)
- Girdling and Scoring
- Growth regulators
- Click pruning

Scoring and girdling

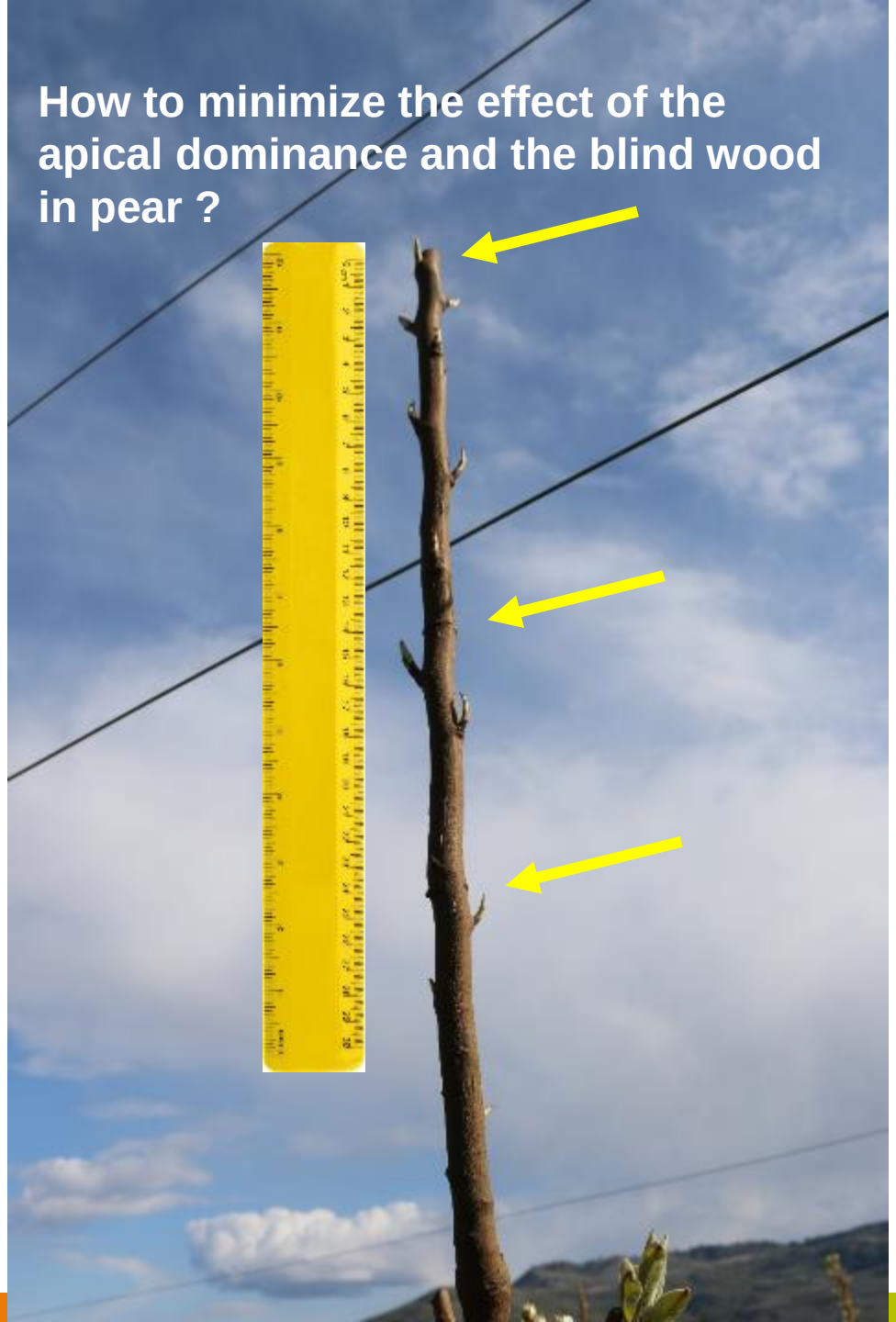
- Scoring is based on **severing the phloem** while **girdling involves bark removal**. Both techniques cause a temporary interruption of movement in the phloem, altering the carbohydrate and hormone balance (Ferree and Scupp, 2003).
- This technique is usually performed with a **double-bladed clipper** or a **small saw** and the wounds heal in a couple of weeks.
- These cuts can **promote bud-break and enhance vegetative growth** on those parts of the trunk that would otherwise not occur.
- These techniques can be applied **in spring (green tip stage) during the first year or, even better, in the second year after planting** when the root system is established and the reaction to the cut will induce a large number of shoots and a strong re-growth.

BLIND WOOD


Girdling:
Precise shoots formation
Girdling, notching and Promalin application can help to promote shoot growth

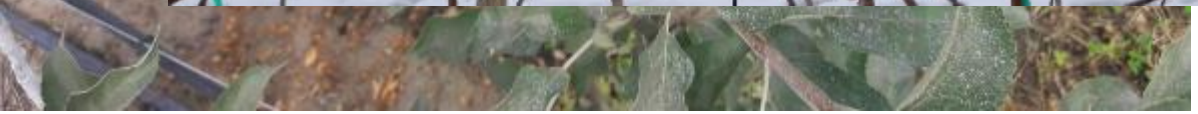
Girdling: Precise shoots formation

How to minimize the effect of the apical dominance and the blind wood in pear ?



Notching

Girdling: an excess of pressure during this operation can snap your axis



Infection risk

- **Note that scoring or, to a lesser extent, bud removal may increase the risk of bacterial canker or fire blight infection.**
- Treatment should be timed to forecasts of several days of **dry weather, and pre-and post-wounding application of antibiotics like copper** may be valuable to reduce bacteria populations.
- Also, bud activation techniques tend to be more successful on newly-planted trees when transplant stress is minimized and on trees with more-established root systems (such as fall-planted trees or **second-year trees** that failed to form the desired shoots in the year of planting).

Technique to enhance precision shoots formation and minimize blind wood

- Stub pruning (Dutch cut)
- Girdling and Scoring
- Growth regulators
- Click pruning

APPLICATION OF GROWTH REGULATORS

- Application of a **cytokinin+gibberellin-based** plant growth regulator, e.g., **Promalin®,** to selected buds at the green tip stage of bud swell.
- Note that this bud activation gives the best results when **temperatures after application are relatively warm;** extended cool temperatures may result in a lack of activity and poor shoot outgrowth.

Technique to enhance precision shoots formation and minimize blind wood

- Stub pruning (Dutch cut)
- Girdling and Scoring
- Growth regulators
- Click pruning

Click pruning

- **This pruning help to prevent blind wood in the basal zone.** For other training systems, such as spindle, on a type 3 or 4 cultivar.
- Click pruning is based on **dormant cutting of 1-year-old wood** in both the apical and basal zone.
- When planting, **feathers are bent to an angle of 40-45°** to the vertical.
- The apical heading of the stem on 1-year-old wood ensures strong regrowth and promotes vigor in the shoots. Making a basal cut into 1-year-old wood prevents the limb from ageing and consequent exhaustion.
- **Once apical dominance is removed, lateral buds on the branches swell instead of remaining dormant.**
- **Click pruning requires that about 20 to 25% of the branches should be renovated every year to maintain a high fruit quality.**
- For this reason, mature trees must have **25-30 small branches to prevent yield reduction.**

Long pruning note the blind wood produced in the first year

Click pruning allowed buds formation close to the trunk and a new shoot

Tree without pruning manipulation

Click pruned and girdled tree

Example of tree obtained following the pruning strategy

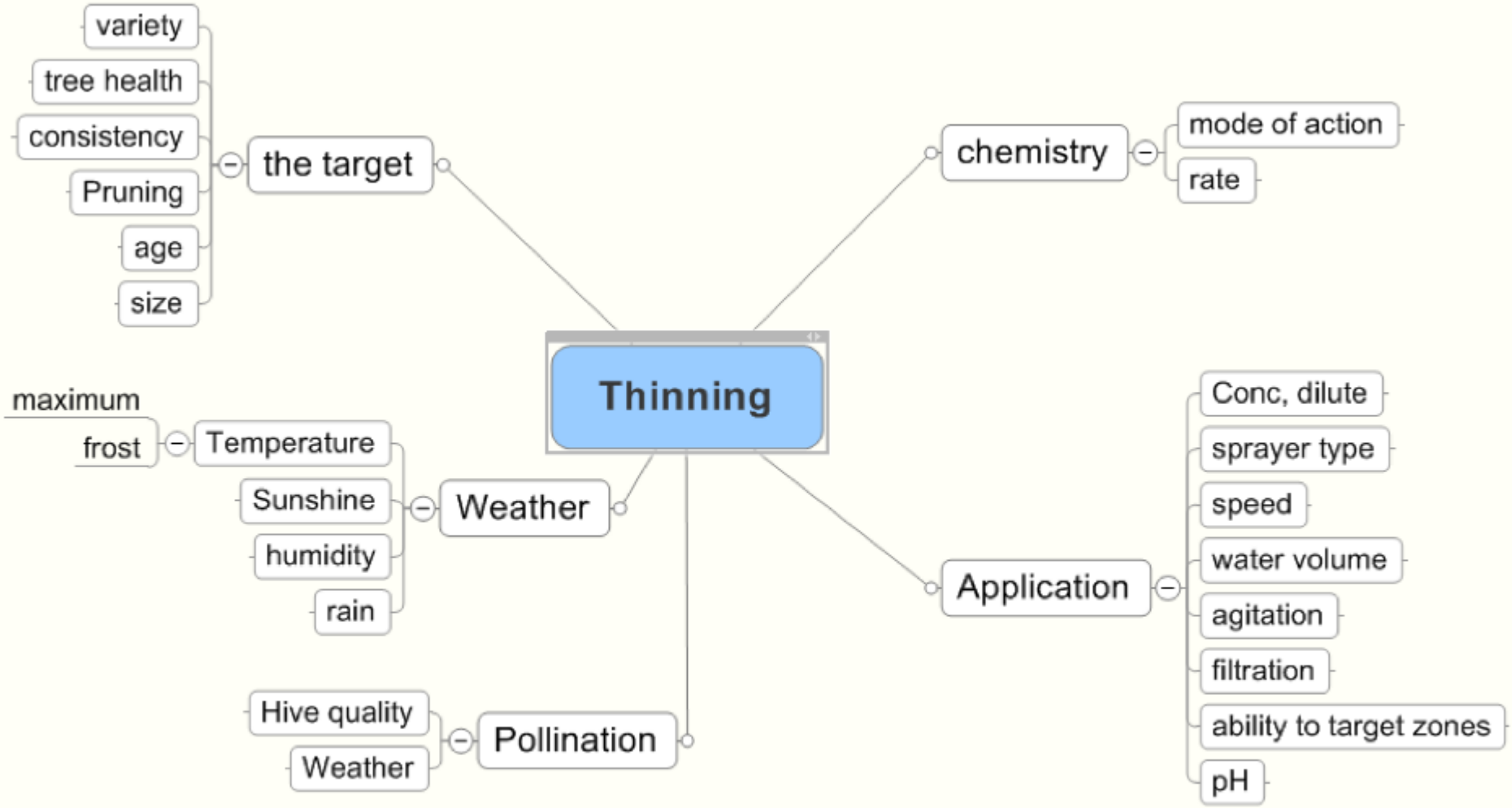
Example of tree obtained following the pruning strategy

Example of tree obtained following the pruning strategy

Example of tree obtained following the pruning strategy

Scoring effects

Factors affecting thinning



Craig Hornblow – AgFirst Consultants, 2009

Physiological Basis of chemical thinning, Current Situation and New Perspectives 1

- Apple may be chemically thinned over a wide period of time starting as early as bloom and extending until **fruit reach about the 25 mm fruit growth stage**.
- **Once the king flower is successfully pollinated, the mode of action of most commonly-used blossom thinners is to inflict some type of lethal damage to the ovary.**
- **Blossom thinners** are routinely used in **arid growing regions**; if they are applied in humid growing climates these compounds may cause some phytotoxicity.
- In addition to potential damage, growers appear to be somewhat reluctant to thin before the pollination period ends and when the **danger of frost has subsided** so that they can assess the initial set.
- **Thinning decisions in humid regions** should be reevaluated since thinning at bloom provides the best opportunity to increase fruit size and ensure return bloom (Batjer and Hoffman, 1951); the perceived danger of thinning at bloom may be more perception than actually documented.
- Petal fall, immediately after bloom, offers another important thinning opportunity.

Physiological Basis of chemical thinning, Current Situation and New Perspectives 2

- **Fruit are most vulnerable to applied thinners during the 8-14 mm growth stage** when typically there are 3-5 fruitlets on each spur and they are in the log growth phase.
- When **a carbohydrate deficient occurs**, an internal signal is given resulting in the abscission of the weakest fruit.
- As fruit **grow larger (>15 mm), they become progressively more difficult to thin** (Greene, 2002; Schwallier, 1996).
- At this **development stage, ethylene production declines**, there is less intra-fruit competition due to earlier fruit abscission and fruit are starting to accumulate starch.
- As fruit approach **17-20 mm diameter, they regain more sensitivity to ethylene and ethephon or 1-amino-cyclopropane-1-carboxylic acid (ACC) application appears to be more effective.**
- **Once fruit grow larger than about 25 mm, further reduction in crop load is generally very difficult.**

B) PRECISION THINNING

- Precision dormant pruning
- Chemical Thinning
- Hand thinning
- Mechanical thinning
- Apple Pollen Tube Growth Model

Precision dormant pruning 1

- Precision thinning starts by growers determining the **goal number of fruit to harvest from a tree or unit.**
- **Setting fruit crop goals is quite easy on new high density plantings** where tree numbers and total desired yield per acre are used.
- It is much more difficult on larger trees where branch subunits are relied upon.
- Thinning at pruning time offers several advantages:

1. **Reduces early competition among flowers.**
2. **Weaker flowers may be pruned off thus allowing resources** and new growth on a tree to be diverted **to the large flower buds** that have a greater potential to produce large fruit.

Precision dormant pruning 2

- Once the target number of fruit per tree is established, the number of flower buds on a tree needs to be determined.
- **Select five uniform and representative trees in a block and count all flower buds**. Calculate the blossom cluster averages for the counted trees. **In some cases 1-1.5% of tree need to be counted.**
- **Multiply the predetermined desired number of fruit on each tree by 1.2 / 1.5** on the basis. This will be the number of flower buds that should remain after pruning.
- Assume an orchard is planted at a 12 x 3 ft (3.6 m x 0.90 m) spacing it would contain 1,210 trees.
- If the desired yield is 1200 bu/acre (59,300 kg·ha-1), then **100 fruit per tree would be the desired final crop load.**
- If you multiply **100 fruit by 1.5 the target number of flowers to remain should be 150. Trees would be pruned to achieve that number.**
- Initially, pruning followed by counting would be required to fine-tune the process.

Variety variation

These ratios are built up over a number of years experience and are specific to NZ

Variety	Winter bud Ratio (winter buds per fruit)
Gala	1 : 1
Braeburn	1.6-2 : 1
Pink Lady	1.5 : 1
Jazz	1.2 : 1

Craig Hornblow – AgFirst Consultants, 2009

B) PRECISION THINNING

- Precision dormant pruning
- Chemical Thinning
- Hand thinning
- Mechanical thinning
- Apple Pollen Tube Growth Model

Thinning Chemicals 1

- Thinning chemicals may be roughly placed in two categories:

1. **caustic thinners**
2. **hormone thinners.**

- **Caustic thinners are generally applied during bloom** with the objective of damaging the flower, preventing the pollen germination or inhibiting pollen tub growth and thus preventing fertilization of the ovule.
- The king flower is generally the largest flower in the cluster and it is the first flower to open so the goal is to assure that the king flowers set fruit while inhibiting set of the remaining lateral flowers.
- **Sometimes the window of opportunity to apply blossom thinner is narrow and can be measured in hours.**
- **Lime sulfur is a very commonly used blossom thinner**, frequently combined with **fish oil or other oils to enhance activity.**
- **Ammonium thiosulfate (ATS) is a foliar nitrogen fertilizer**. Although not specifically registered for use as a thinner on apples, if ATS is applied to trees at bloom at a rate of 2-4 gal/acre (18.8-37.5 L·ha-1) is has been shown to be a viable thinner.

Thinning Chemicals 2

- **Blossom thinners are routinely used in dry, low humidity climates**.
- If blossom thinners are applied before wet or high humid periods it is not uncommon to have a significant **amount of foliage damage**.
- **Spur leaves are very important to support fruit cell division/early growth.**
- **The observation has been made that application of blossom thinners in wet conditions may lead to thinning but may not manifest in increased fruit size at harvest due to foliage damage.**
- **Blossom thinning removes fruit early**, thus providing the best opportunity to **assure return bloom**. It therefore remains a viable option to use, especially on cultivars that are noted for biennial bearing.

Proven chemical bloom thinners of apple

Incidence of results significantly superior to untreated control.
WTFRC apple chemical bloom thinning trials 1999-2018

Treatment	Fruitlets / 100 blossom clusters	Harvested fruit diameter	Return bloom[1,2]
ATS	15 / 60 (25%)	10 / 63 (16%)	4 / 55 (7%)
NC99	15 / 32 (47%)	7 / 34 (21%)	2 / 28 (7%)
Lime sulfur	26 / 58 (45%)	12 / 52 (23%)	9 / 52 (17%)
CFO + LS	62 / 115 (54%)	27 / 106 (25%)	22 / 105 (21%)
JMS + LS	14 / 24 (58%)	8 / 23 (35%)	4 / 22 (18%)
WES + LS	15 / 31 (48%)	5 / 30 (17%)	4 / 29 (14%)
ThinRite	7 / 22 (32%)	0 / 23 (0%)	0 / 12 (0%)

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[1]Does not include data from 2018 trials.
[2] (no. blossom clusters year 2/sample area) / (no. blossom clusters year 1/sample area)

Proven chemical postbloom thinners of apple

Incidence of results significantly superior to untreated control

WTFRC apple chemical postbloom thinning trials 2002-2018

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Treatment	Fruitlets / 100 blossom clusters	Harvested fruit diameter	Return bloom[1,2]
BA	6 / 27 (22%)	0 / 28 (0%)	0 / 24 (0%)
Carb + BA	33 / 91 (36%)	10 / 89 (11%)	13 / 86 (15%)
Carb + NAA	25 / 73 (34%)	18 / 71 (25%)	11 / 67 (16%)
BA + NAA	18 / 40 (45%)	9 / 39 (23%)	7 / 36 (19%)
Metamitron	13 / 24 (54%)	8 / 23 (35%)	5 / 18 (28%)

[1]Does not include data from 2018 trials.

[2] (no. blossom clusters year 2/sample area) / (no. blossom clusters year 1/sample area)

2017 metamitron phytotoxicity

Granny Smith/M.9 – Rock Island, WA

2017 metamitron phytotoxicity

Jonagold/M.9 – Rock Island, WA

Metamitron summary 2017

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- **Works well on all varieties in WA trials, but will require aggressive rates & multiple applications for effective thinning in most seasons**
- Possible to **overthin during hot, cloudy weather**, but less so than some standard thinners
- **Phytotoxicity** may be concerning for application temps **above 85 F° (30 C°)**
- **Efficacy increases with NIS** (i.e. Regulaid); tank-mixing with other thinners may not be needed
- Registrant working on instrumentation and model to guide application recommendations
- **Registration still several years off pending** EPA required studies & subsequent review

B) PRECISION THINNING

- Precision dormant pruning
- Chemical Thinning
- Hand thinning
- Mechanical thinning
- Apple Pollen Tube Growth Model

Hand blossom thinning

- **Very expensive** & time-consuming
- Almost **guarantees positive effects on fruit size**, quality, and return bloom
- Can be **risky if frost kills flowers**
- **Hard to decide how aggressive to be** (thin to target crop load or leave some extra flowers that will need to be thinned later?)

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Ideal scenario for hand blossom thinning

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- **Premium cultivar** which can afford high production costs (i.e. Honeycrisp, Envy, Ambrosia, Jazz)
- **Grower has plenty of available labor** to keep busy during bloom (i.e. H2A workers)
- **Orchard has highly formalized canopy structure** with simple rules for target fruiting (e.g. 5 fruit on every branch and 2 fruit on leader between each trellis wire)
- **Mobile platforms** to improve labor efficiency

B) PRECISION THINNING

- Precision dormant pruning
- Chemical Thinning
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- Apple Pollen Tube Growth Model

DARWIN

April 15, 2010
Open cluster
40-50% open flowers

Darwin:

250 rotation/minute

Speed 6-7 km/hour

Mechanical thinning 1

Mechanical thinning 2

B) PRECISION THINNING

- Precision dormant pruning
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WSU AgWeatherNet

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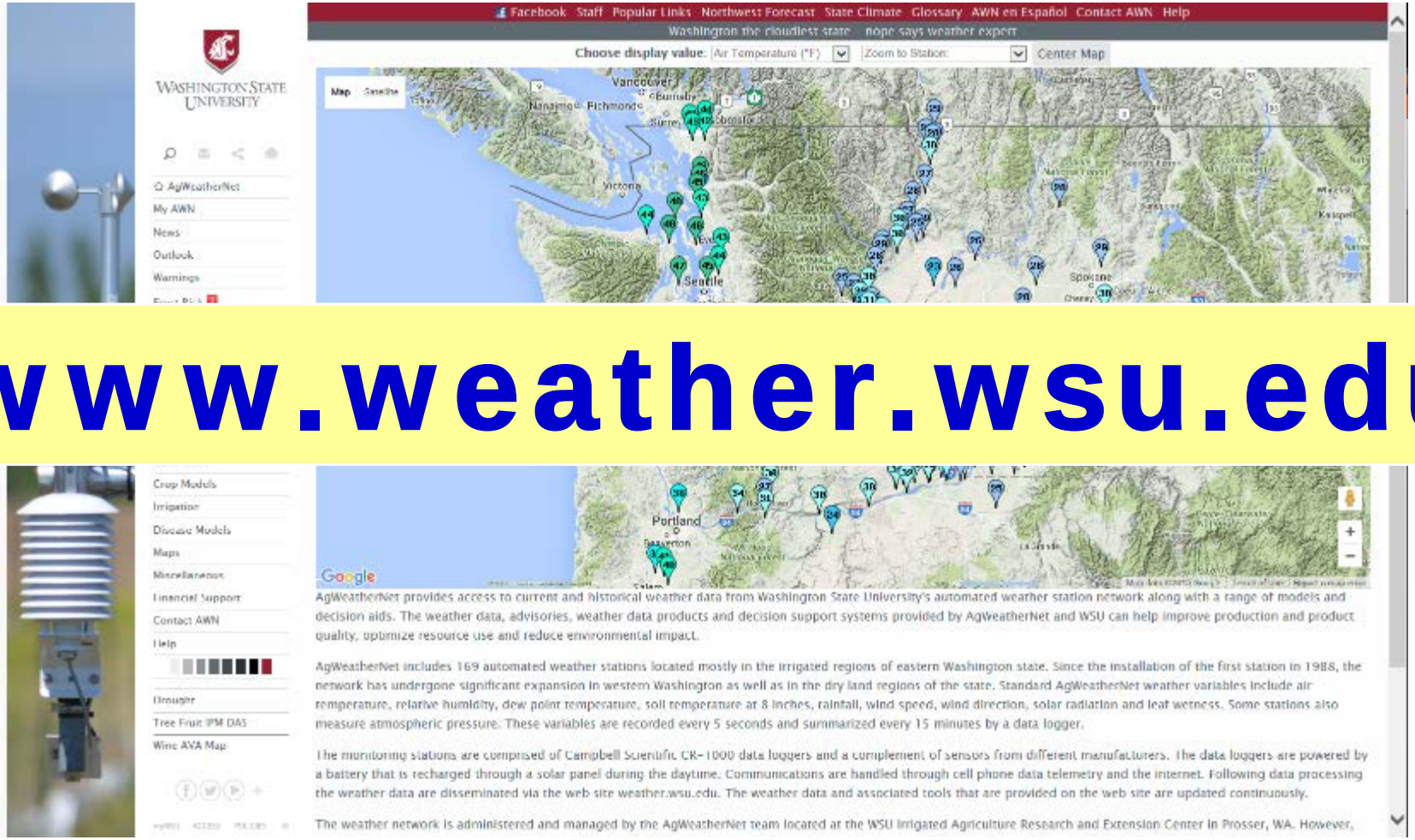
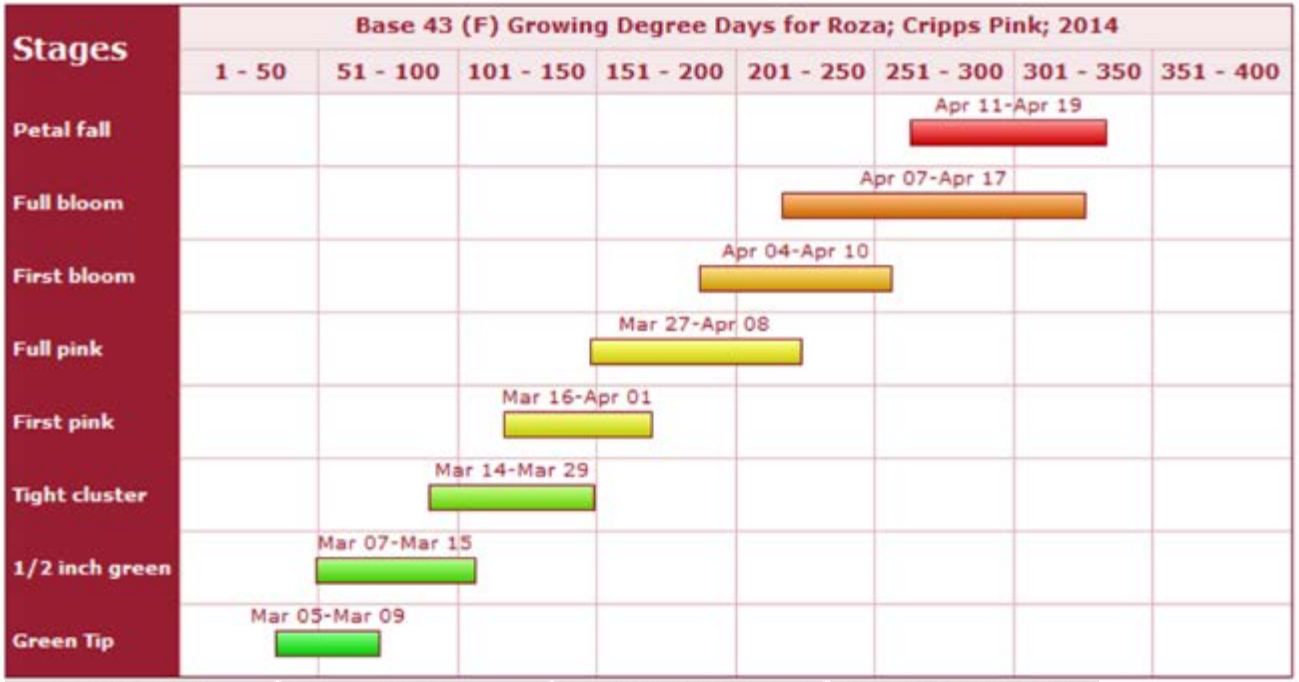


www.weather.wsu.edu

Bloom phenology model



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WSU Sunrise AWN

Jump To | Edit Station | View Conventional

Blooming - Gala

Conditions | Data Table | Weather Forecast | About Model

Last Updated: 05/01/2017

Degree days on 05/01/2017 since January 1st. = 498

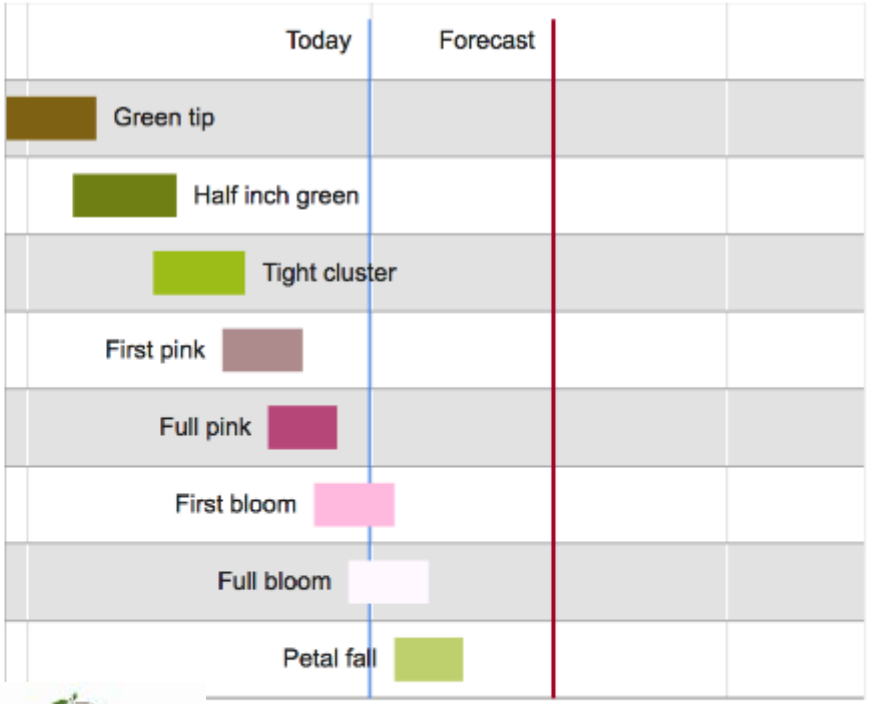
Current Conditions:

Stage	Total % today	Reached 90%...	Forecast %
Green Tip	100%	Fri, Apr 07	100%
Half inch Gre...	100%	Fri, Apr 14	100%
Tight Cluster	100%	Thu, Apr 20	100%
First Pink	100%	Tue, Apr 25	100%
Full Pink	97%	Fri, Apr 28	100%
First Bloom	69%	Wed, May 03	100%
Full Bloom	21%	Sat, May 06	100%
Petal Fall	1%	Tue, May 09	100%

Forecast :

+16 days Wed May 17, 2017 : 730 DD

N.B.: Chart shows 10%-90% of development



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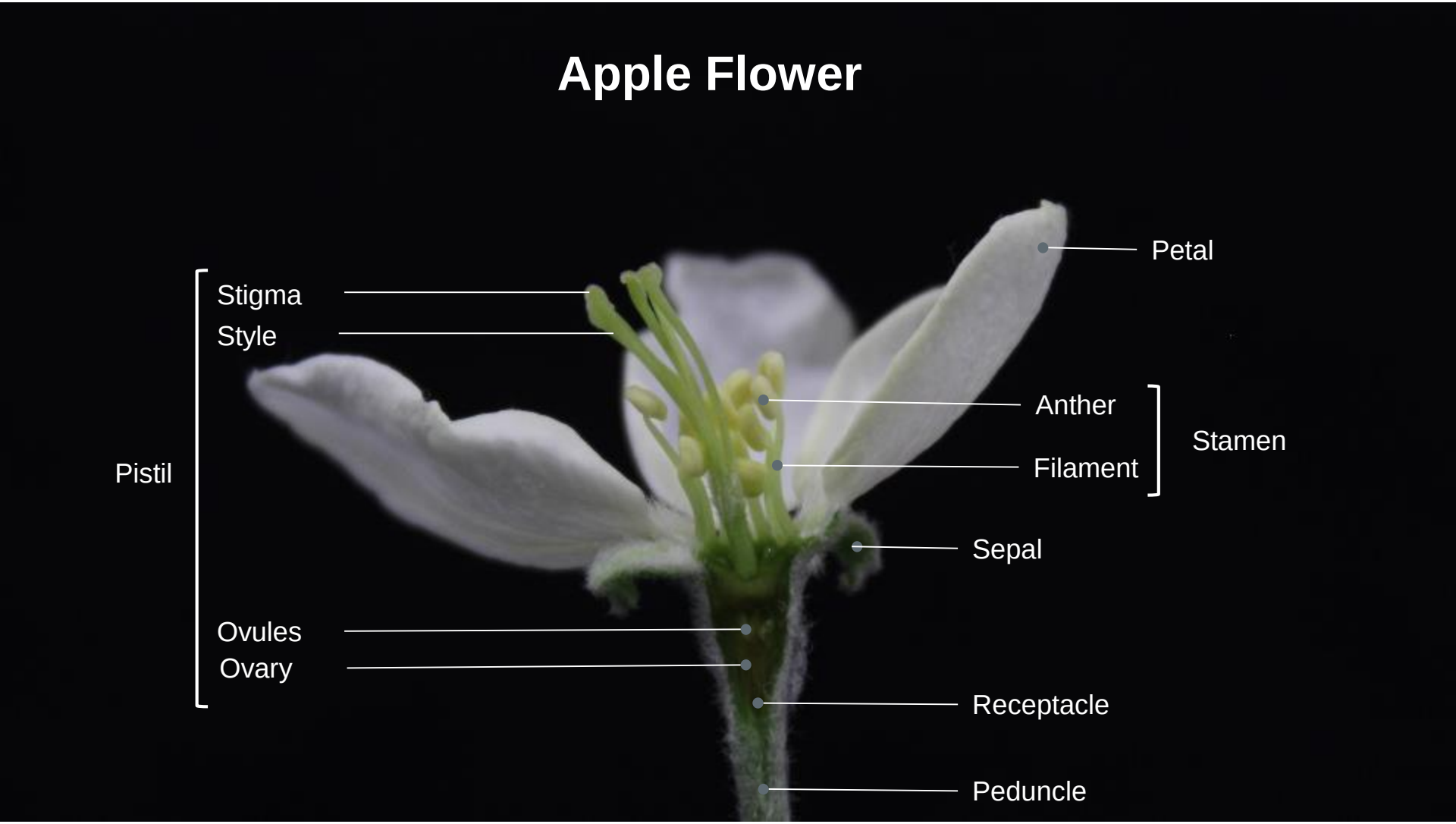
Pollen Tube Growth Model 1

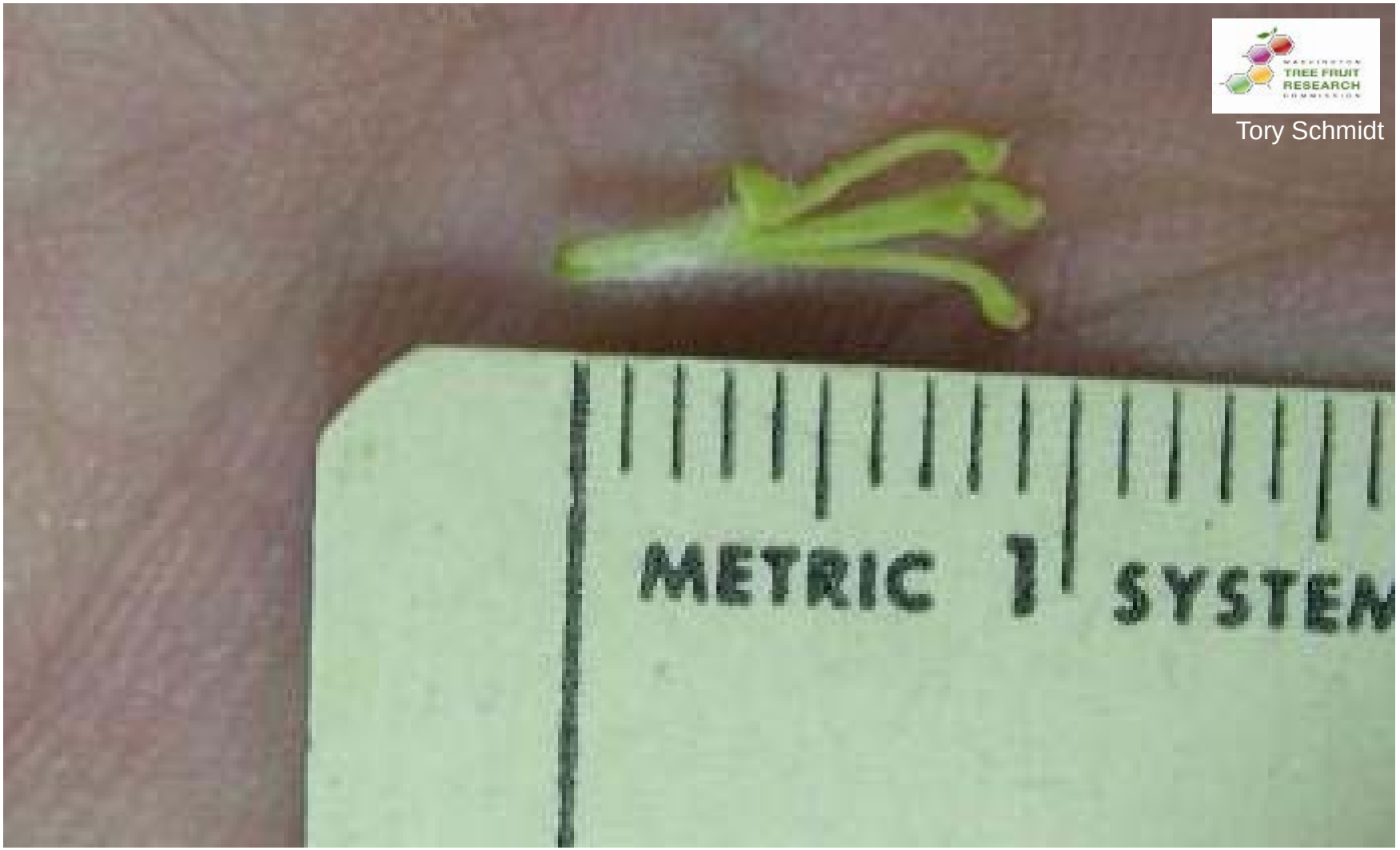
- **Blossom thinners can be very erratic since timing is critical for success.** Ideally, there should be a **sufficient number of king flowers open and pollinated to achieve a full crop.**
- Once this is accomplished a blossom thinner should be applied to prevent pollination of the remaining flowers. **Timing of the spray is important to the success of blossom thinners.**

Pollen Tube Growth Model 2

- The pollen tube growth model **was developed to provide guidance to accurately time the application of the blossom thinners** (Peck et al., 2015; Yoder et al., 2013).
- **Temperature influences the rate for pollen tube growth.**
- The **length of the style is initially measured, and taking temperature into account, the model indicates the time required for the pollen tube to grow through the style to fertilize the ovule.**
- As soon as **the model predicts the pollen tube has reached the ovules in the ovary, the blossom thinner should be applied to discourage pollination and fertilization of all lateral or remaining flowers.**
- Since **pollen tubes grow at variable rates in different cultivars**, a model for each cultivar must be established.

Apple Flower





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AFTER REMOVAL MEASURE ONLY LONGEST STYLE ON EACH FLOWER SAMPLED.

Apple pollen tube growth model 3

- **Predicts how long it takes for flowers of different cultivars to be fertilized after they have been pollinated based on ambient temperature.**
- This information can help inform crop load management decisions, especially **timing of chemical bloom thinners** (no more guesses like 20 & 80% bloom)
- **It's a tool, not a silver bullet!**

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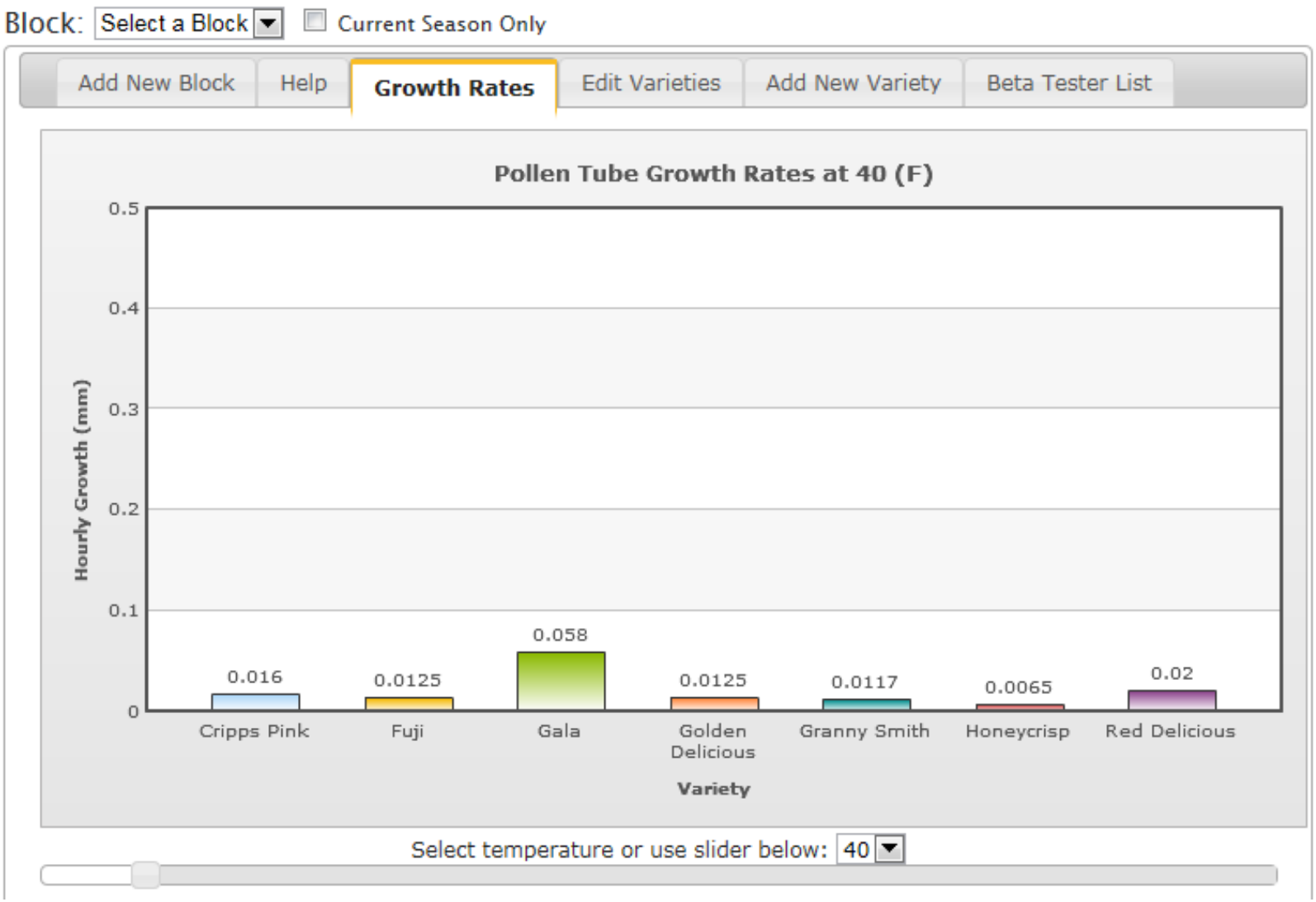
Growth rates at low temperature



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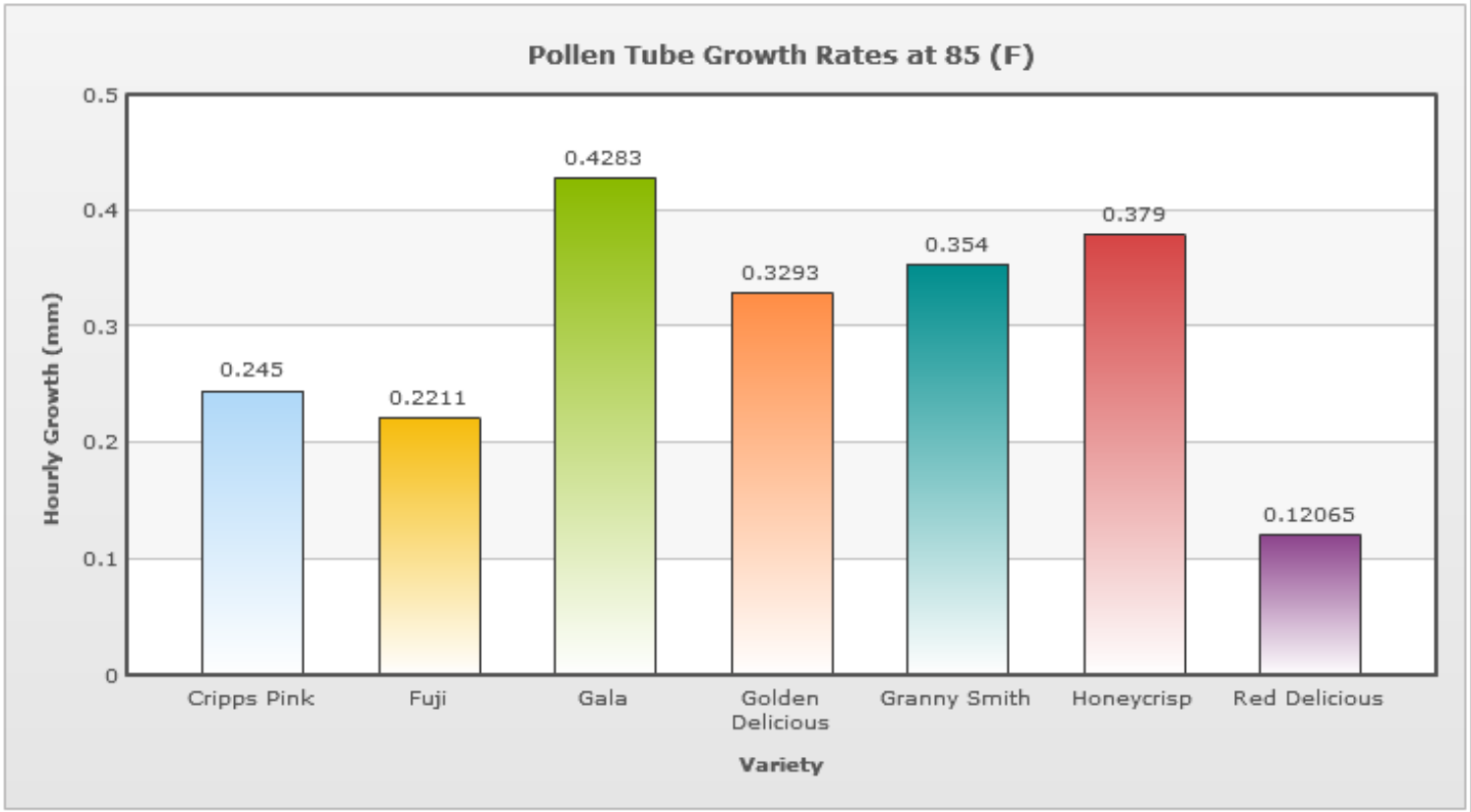
Growth rates at high temperature

Block: Select a Block ☐ Current Season Only

Add New Block | Help | **Growth Rates** | Edit Varieties | Add New Variety | Beta Tester List



Select temperature or use slider below: 85

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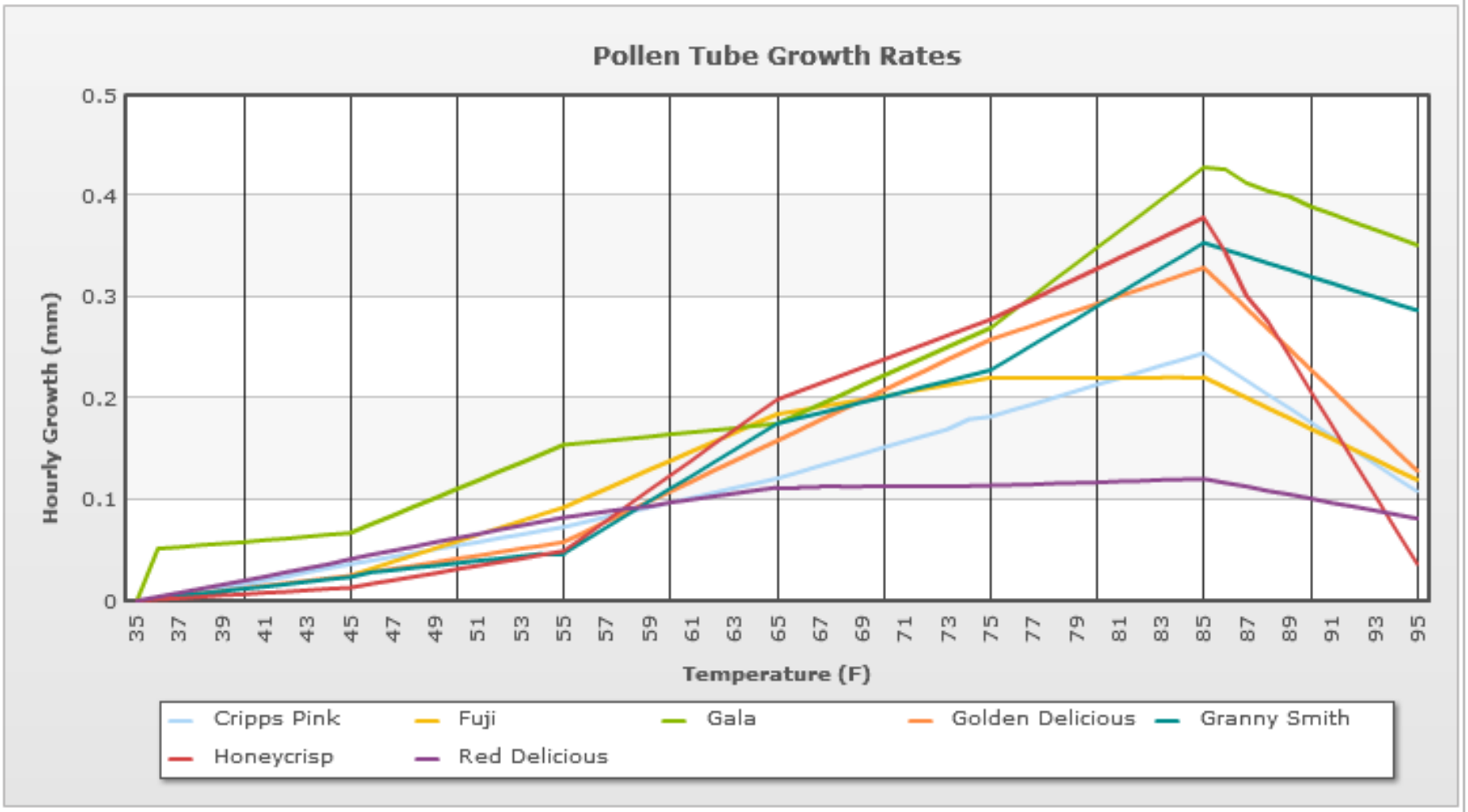
Growth rates by cultivar



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Hypothetical example 1

- Gala block where larger fruit is desired
- Spacing: 3’ x 12’ = **1210 trees/acre**
- Desired yield: **60 bins peaking on 88s**
- 60 bins x 24 boxes x 88 fruit = 126,720 fruit/acre or **105 fruit/tree**
- As soon as typical trees have 105 flowers open, “**start the clock**” (activate pollen tube growth model)

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Hypothetical example 2

- **Apply first bloom thinning spray** when model hits 100-110% of mean style length – the timing of this spray determines your fruit set
- **Entering spray timings reset the model to track tube** growth in newly opened flowers
- **All subsequent sprays should be made when model is no more than 75% of style length** to ensure no more fruit set
- Strategy may be different in other scenarios (e.g. you want to set more lateral bloom)

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Good spray timings

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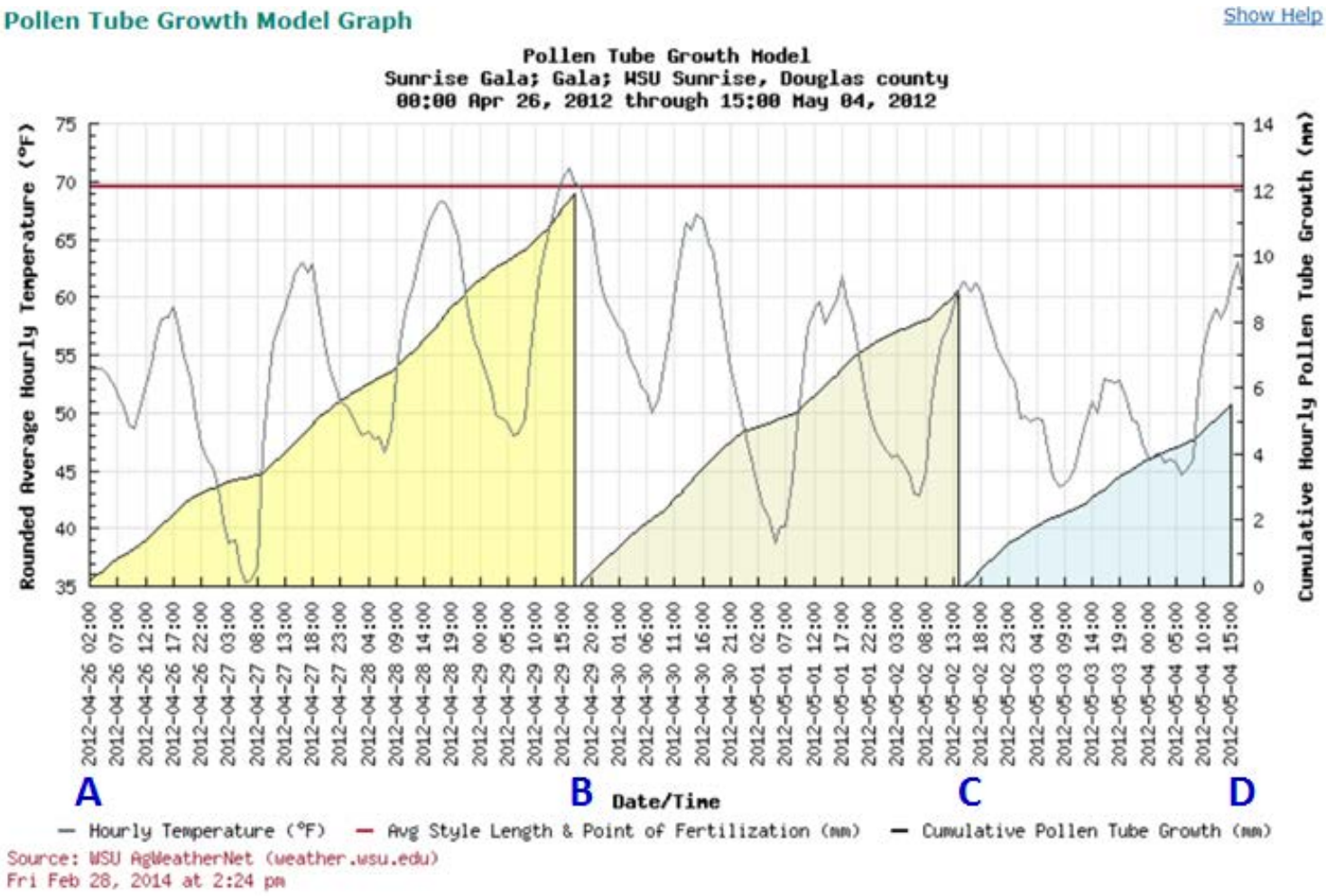

Bad spray timings

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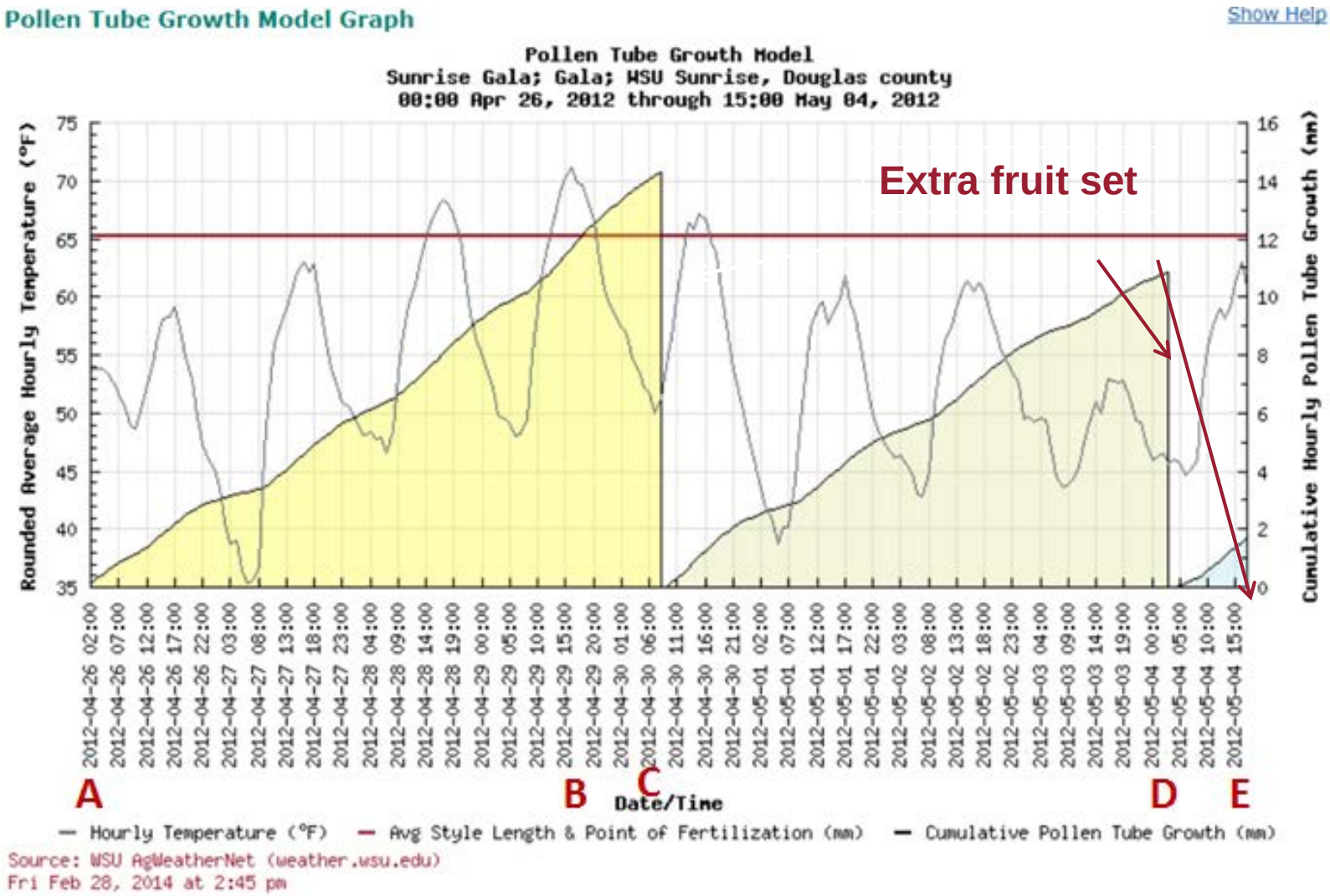

Model limitations

- Assumes **optimal bee activity and pollen availability/viability**
- **No models for secondary or niche varieties**
- Unresolved questions about **role of pollen source**
- Based on use of **lime sulfur thinning programs and makes overly simplistic assumptions about how they work**

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PTGM cultivar releases

- 2014
  - Gala, Fuji, Golden Delicious, Cripps Pink
- 2017
  - Honeycrisp, Granny Smith
- 2018
  - Red Delicious

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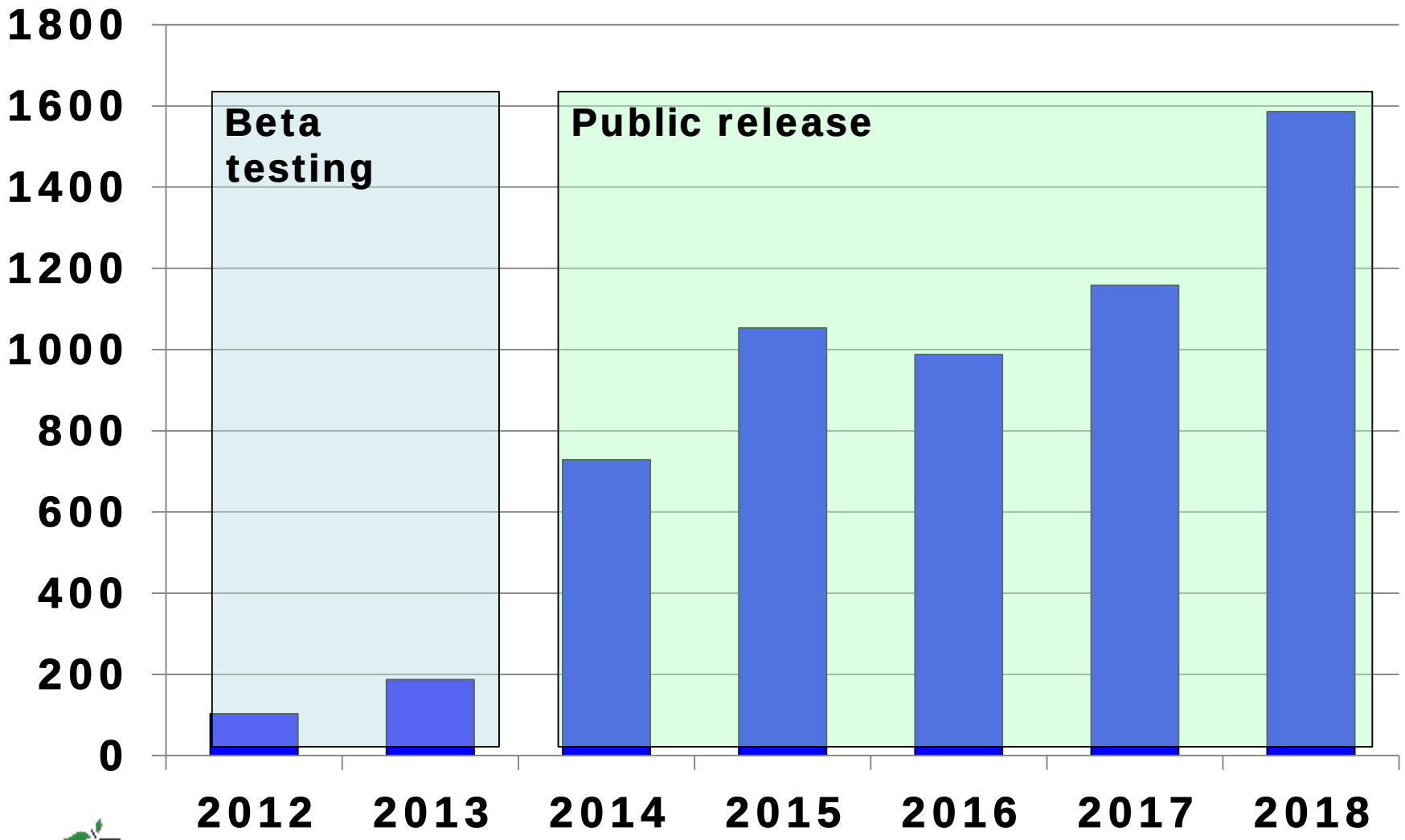
Pollen tube growth model blocks registered with AWN



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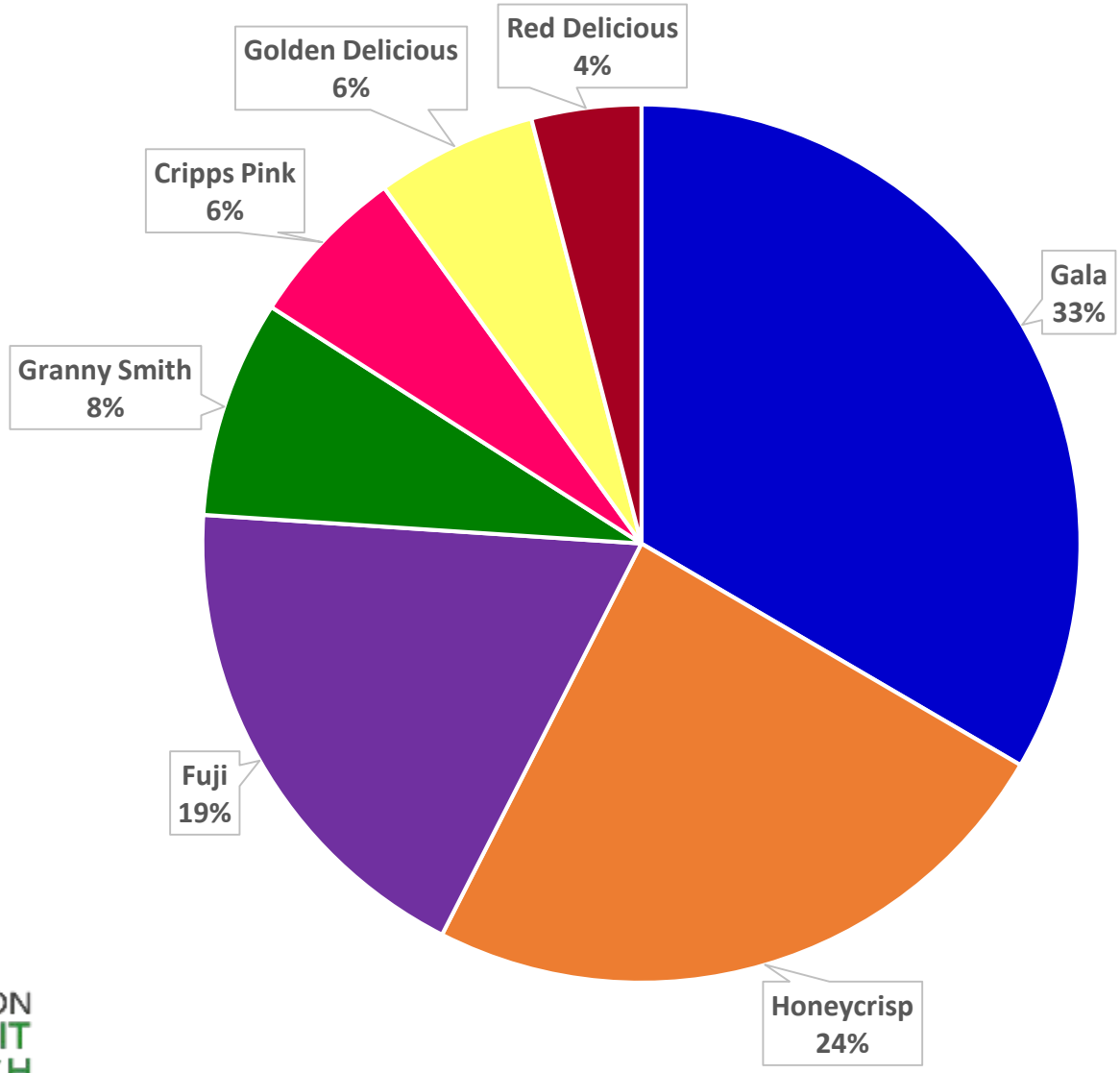
AWN-registered PTGM blocks by cultivar -2018



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Thank you for your attention !!!

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