SUMITOMO CHEMICAL
AgroSolutions Division - International

VALENT BIOSCIENCES

Some Practical Advice from 30 Years of Chemical Thinning Research

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Valent BioSciences LLC

April, 2019

Creative Hybrid Chemistry

Topics to be covered…

Chemical thinning

- Benefits and importance
- Some underlying physiology that will help you make better decisions
- A unifying hypothesis – carbohydrate balance in the fruit is key
- Why product formulation is so important
- Life without carbaryl
- Putting it all together in a program
- ACC – something new for the future

Promalin

- Programs for fruit size enhancement
- An effective frost rescue treatment

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The triple benefits of a successful thinning program

Benefit #1: Increased fruit size and crop value

Fruit size potential is determined within 40-50 days of bloom

A small apple at the end of the cell division phase is going to be a small apple at harvest

The earlier that you can establish the final crop load the larger fruit size will be at harvest

The triple benefits of a successful thinning program

Benefit #2: Reduced hand thinning costs

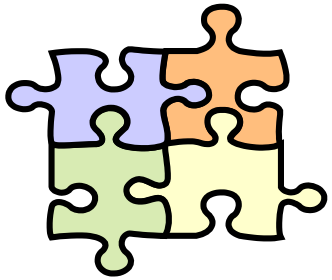
Hand thinning will normally occur <u>after</u> the cell division phase is finished

"You can make a big apple small but you can't make a small apple big!"

The triple benefits of a successful thinning program

Benefit #3: Reduced risk of triggering a biennial bearing cycle

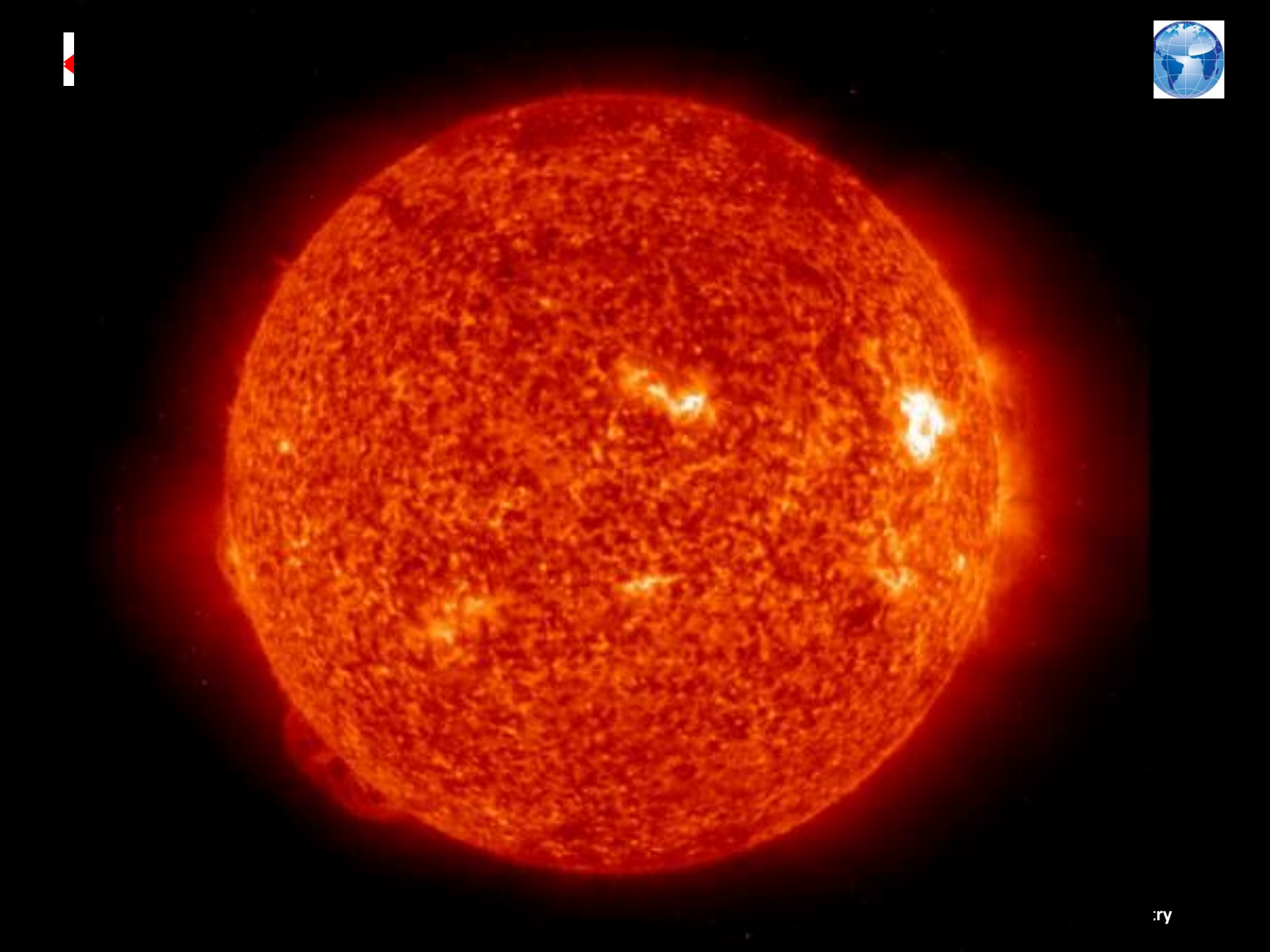
Initial fruit set
Initial seed set



Success of chemical thinning program

Summer NAA and
Ethrel programs

Other factors:
- Nutrition
- Tree vigor
- ???



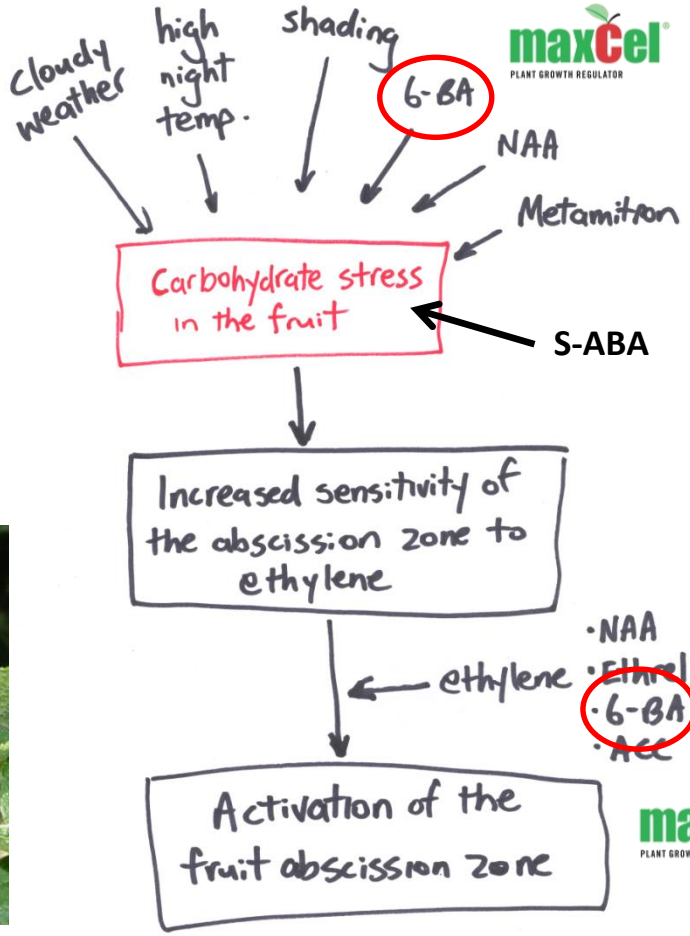
Why is light (and heat) important for fruit set?

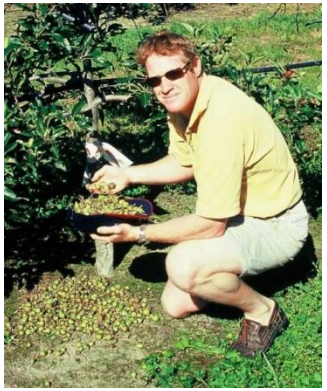
During the period when thinners are applied, the carbohydrate supply from current photosynthesis is in balance with the demand from the different organs (roots, young shoots, fruit, wood), with the daily balance depending on the amount of sunlight and the temperatures experienced for that day

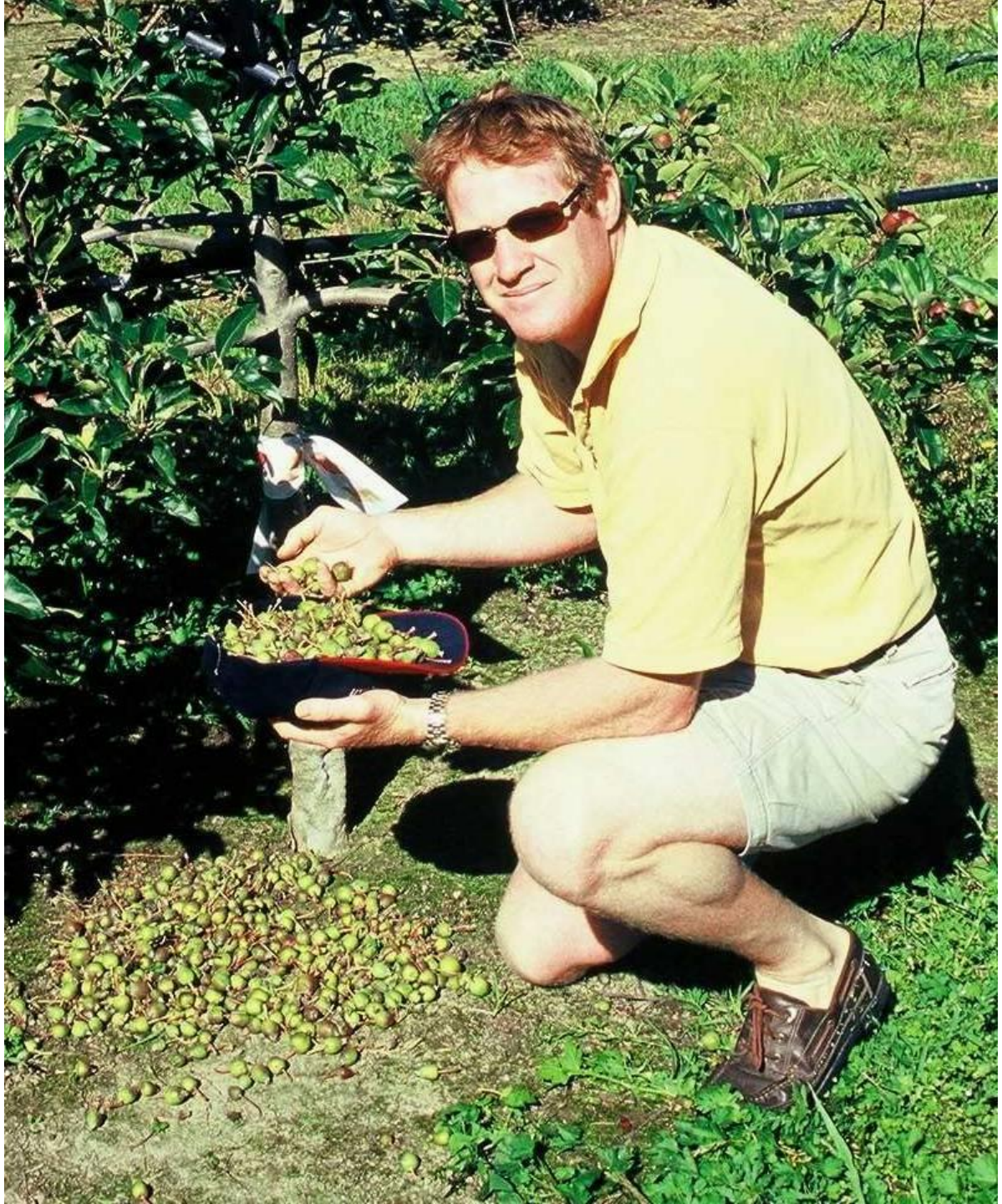
A shortage of carbohydrates results in competition between fruit and shoots

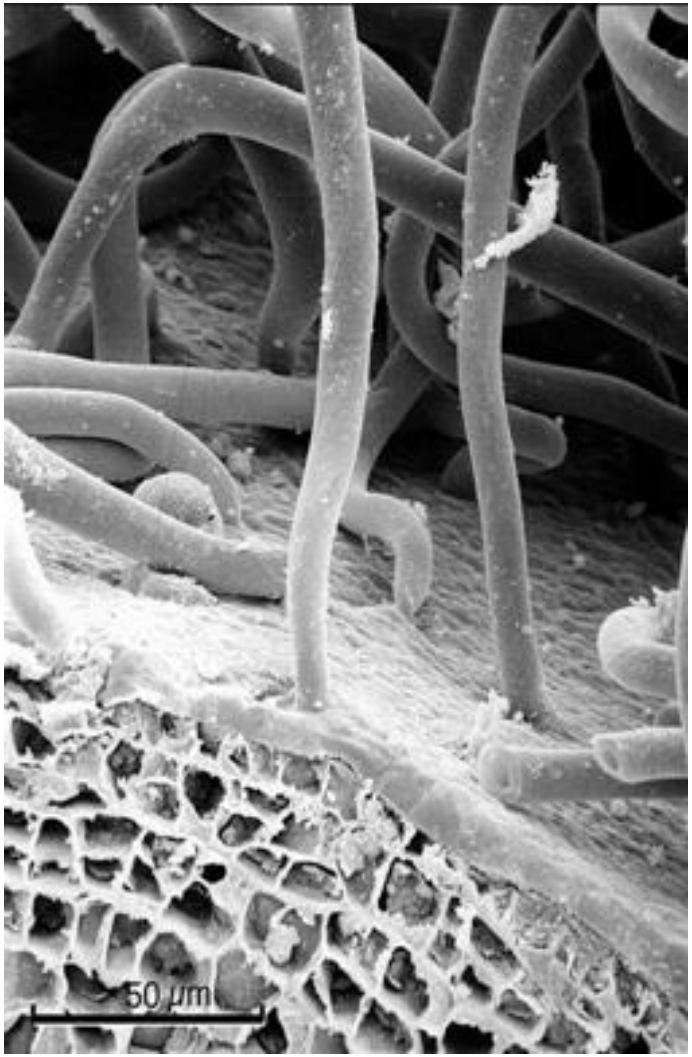
Fruit are weaker sinks than shoots at this time

CARBOHYDRATE STRESS IN THE FRUIT INTEGRATES THE EFFECTS OF ENVIRONMENT AND CHEMICAL THINNERS ON FRUIT SET



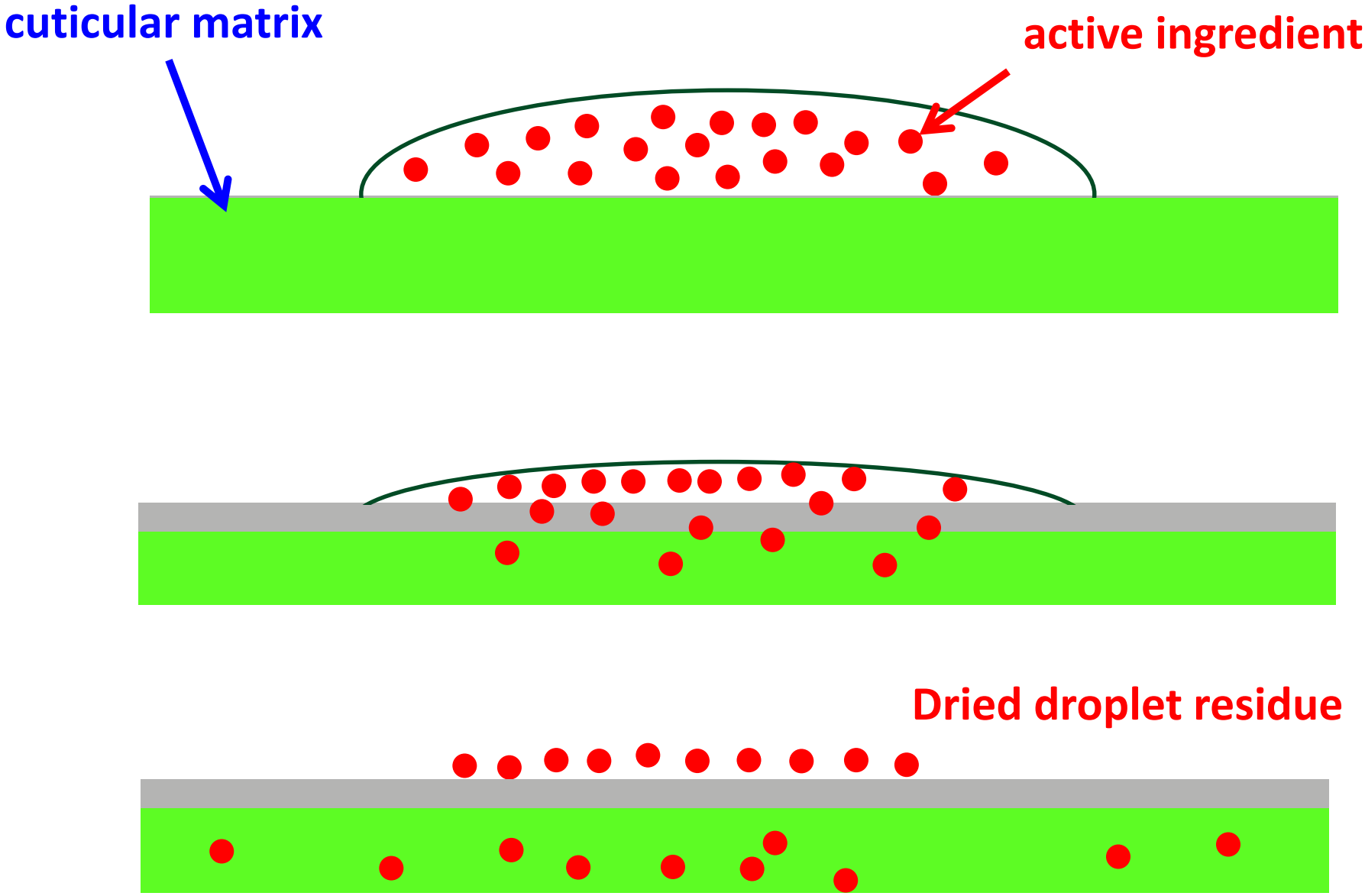






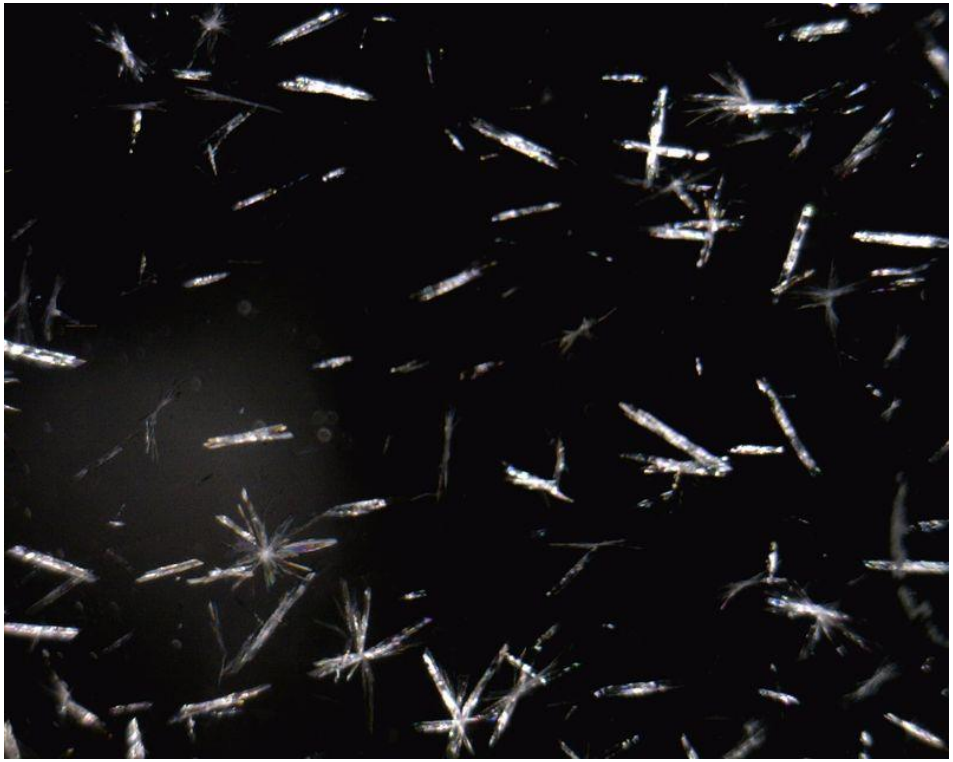
Source: Martin Goffinet

- The fruit cuticle is 2-3 micrometers thick at bloom
- Thickness increases to around 15 micrometers at harvest



Droplet contact area, drying time and penetrants will influence uptake

WATER-BASED FORMULATIONS CAN HAVE SOLUBILITY PROBLEMS



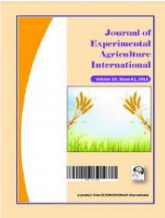
- Poorly formulated 6-BA product results in crystallization in solution
- Photograph shows 6-BA crystals in a solution of 150ppm

Efficacy of different 6-BA products (PC FRUIT)

Tabel. *Vergelijking BA-dunmiddelen op peer (Conference) en appel (Rockit) in 2016*

Peer: **Conference**	Bloemknoppen	Vruchten	Vruchten/ 100 clusters	Percentage
Controle	148	131	89	100
Globaryll 2 l/ha	154	108	71	80
MaxCel 10 l/ha	152	89	53	59
Exilis 10 l/ha	150	125	86	97
Appel: Rockit				
Controle	131	180	137	100
Globaryll 1,5 l/ha	123	160	130	95
MaxCel 7,5 l/ha	111	122	111	81
Exilis 7,5 l/ha	109	141	130	95

Bron: Pcfruit



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Different Sources and Concentrations of 6-BA in Chemical Thinning of Post-flowering in Apple Trees

Gentil Carneiro Gabardo[1*], José Luiz Petri[2], Aike Anneliese Kretzchmar[1], Mariuccia Schlichting de Martin[2], André Amarildo Sezerino[2] and Willian Coser[1]

[1]Santa Catarina State University, Agroveterinary Sciences Center, Lages, Brazil.
[2]EPAGRI/Caçador Experimental Station, Caçador, Brazil.

BA is efficient in fruit thinning in 'Fuji Suprema' apple trees, being the reduction of fruiting, and increase of fruit size, proportional to the applied concentration. There may be differentiated efficiency of the product by its formulation, even though they have concentrations of active ingredient equivalent. Exilis® was efficient in thinning of apple "Fuji Supreme", when applied to fruit 5 to 10 mm in diameter reduced the need for manual thinning, without causing toxicity. BA can

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MaxCel® Use Rates by Variety and Thinning Difficulty

maxCel™

Concentration	Product Rate per Ha (in 1000 L)	Comments
50 ppm	2.5 L / ha	Use for size enhancement. Make 2-4 apps at 3-10 day intervals starting at PF.
75 ppm	3.7 L / ha	Use for moderate thinning on varieties such as McIntosh, Paulared, Spartan, and Gingergold
100 ppm	5 L / ha	Use for most thinning situations. This rate has worked well on Gala, Empire, Golden Delicious and Red Delicious
150 ppm	7.5 L / ha	Use in orchards that have very difficult to thin cultivars such as Fuji or have a history of being difficult to thin.

MAXCEL® IN AN APPLE THINNING PROGRAM

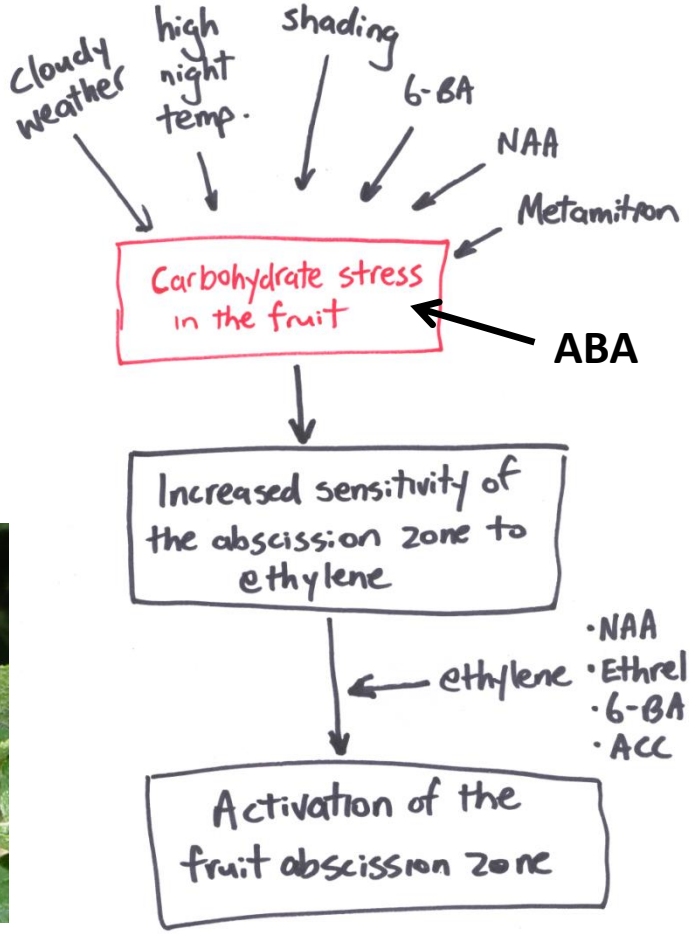
E **F1** **F2** **G** **H** **7 mm** **15 mm** **25 mm**

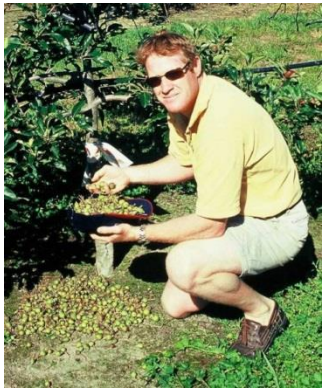




Ethéphon	ATS Mechanical	NAD	NAA 6BA metamitron	Ethéphon
PRM 12® RP		Amid Thin® W	Rhodofix® Fixor® MaxCel® Brevis®	PRM 12® RP

CARBOHYDRATE STRESS IN THE FRUIT INTEGRATES THE EFFECTS OF ENVIRONMENT AND CHEMICAL THINNERS ON FRUIT SET





Publication 360, 2018-19 Fruit Crop Protection Guide

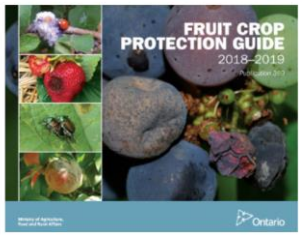


Table 2–10. Suggested Rates of MaxCel or Cilis Plus to Use With or Without Sevin XLR

Desired response[1]	Concentration of 6-BA (ppm)[2]	Concentration of Carbaryl (ppm)[2]	Number of Applications	Amount of MaxCel or Cilis Plus		Amount of Sevin XLR (L/1,000 L water/ha)
				MaxCel (L/1,000 L water/ha)	Cilis Plus (L/1,000 L water/ha)	
Enhance size only[3,4]	10–50	—	2 to 4	0.5–2.65	0.5–2.5	—
Mild thinning a[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	
Moderate thin						
Aggressive thi						
Very aggressi						

— = Informatic

[1] There are se
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[3] Mild thinning
[4] While 6-BA h
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Precautions

Do not apply MaxCel or Cilis Plus in combination with the hormone thinner, NAA (naphthaleneacetic acid), either as a tank-mix or separate sprays during the same growing season. Doing so may result in pygmy fruit.

Can NAA replace Carbaryl in 6-BA mixes?

Thinning without Carbaryl

As a rule of thumb 7.5ppm NAA can replace:

1 pint Carbaryl/100 gal ≈ 7.5 ppm NAA (3oz Fruitone L)

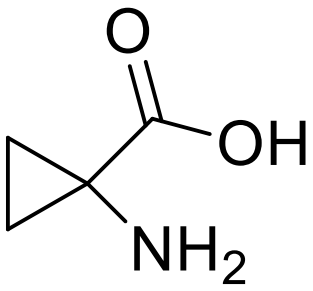
1 L Carbaryl /1000L ≈ 7.5 ppm NAA (200 ml/1000L Fruitone L)

in moderate to hard-to-thin varieties

However, this does not apply for varieties such as Fuji and Red Delicious as pygmy fruit may result.

EXCITING FUTURE FOR PGR's FROM VBC

1-Aminocyclopropane carboxylic acid (ACC)



- Naturally occurring amino acid.
- Present in all major land plants (fruit, vegetables, grains, nuts, etc.).
- Immediate precursor of the plant hormone ethylene
- VBC holds numerous patents
- VBC has been studying ACC for a variety of commercial applications.

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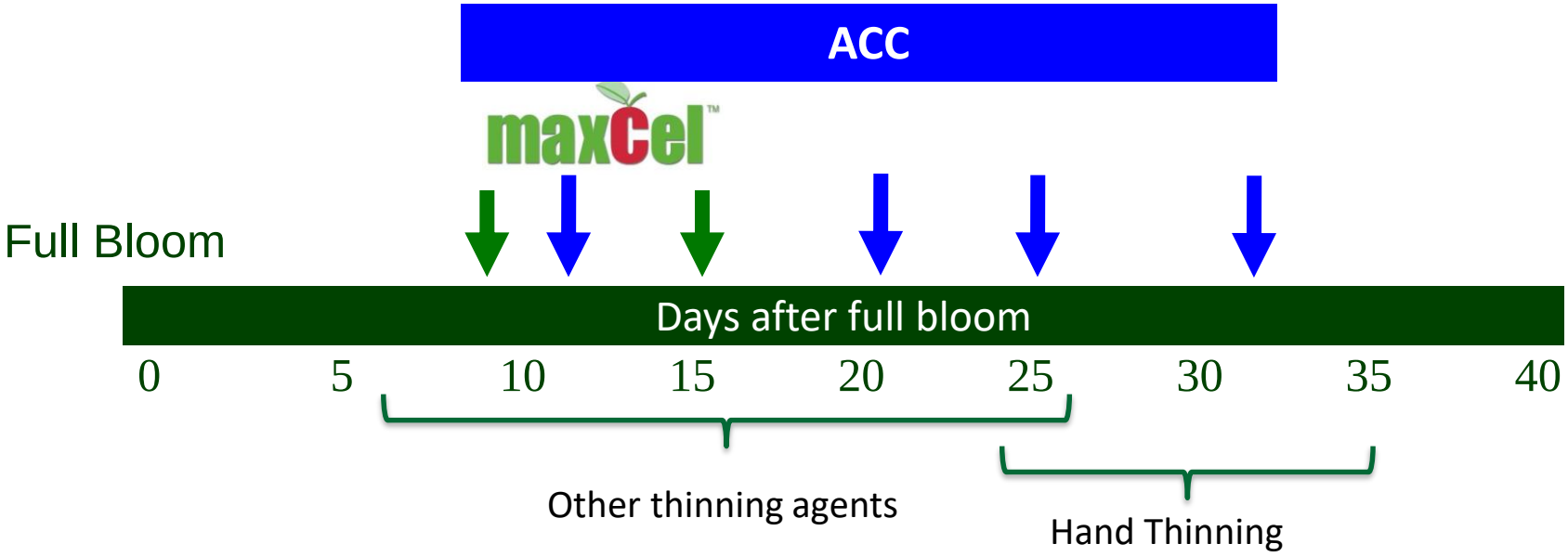
ACC IS A VERY EFFECTIVE LATE APPLE THINNER

3 days after applying ACC to 'Cameo' at 19 mm

POSITIONING ACC IN AN APPLE THINNING PROGRAM







ACC THINS STONE FRUIT

Trial #3 App A 600 ppm 7 DAT March 15th on Black Beaut Plums.-Visalia, CA

Promalin®
PLANT GROWTH REGULATOR

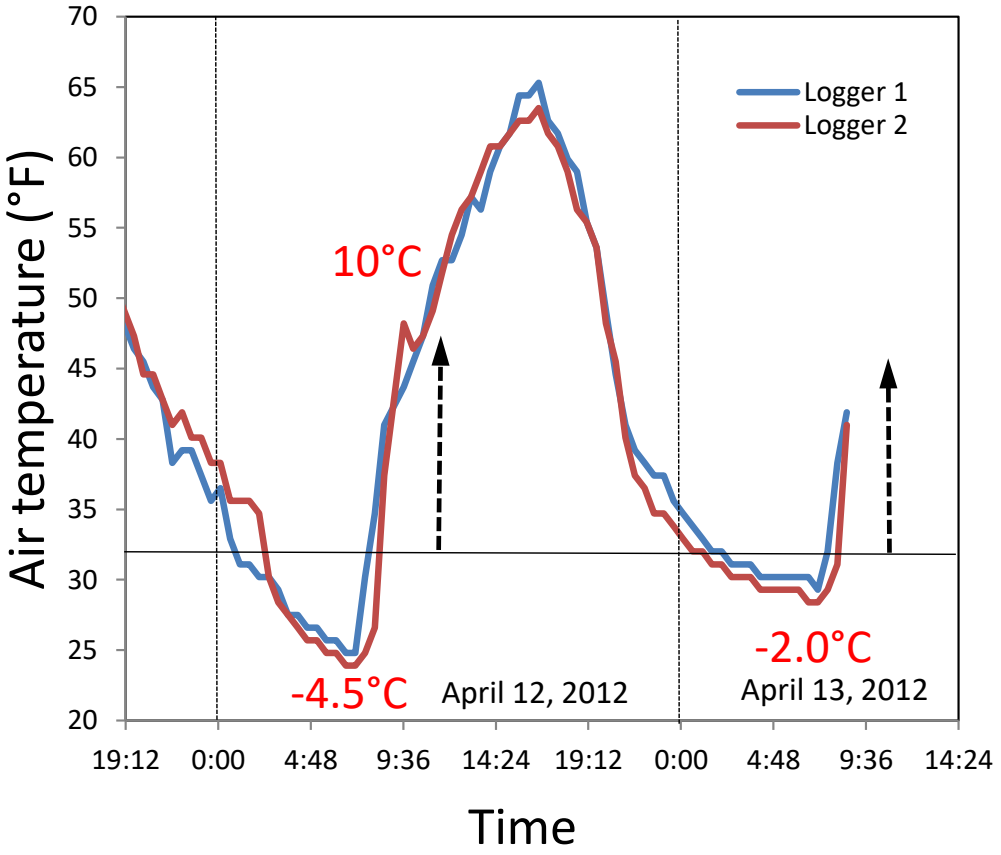



- Gibberellins A4+7
  - Promotes cell expansion -increase fruit size
  - Apples
    - Improves fruit shape
    - Increase size
    - Sets parthenocarpic fruit after a frost
- 6-Benzyladenine
  - Promotes cell division
  - Increased fruit size
  - Stimulates branching

PROMALIN® FROST RESCUE TREATMENT (APPLE)

PROMALIN® FROST RESCUE TREATMENT (APPLE)

Apple cv. 'Rome Beauty'



Arrows indicate when Promalin® was sprayed

APPLE FLOWERS ARE MOST SENSITIVE TO LOW TEMPERATURE DURING BLOOM

Wytrzymałość na mróz pąków kwiatowych, kwiatów i zawiązków jabłoni na przedwiośniu i wiosną (Westwood 1978)

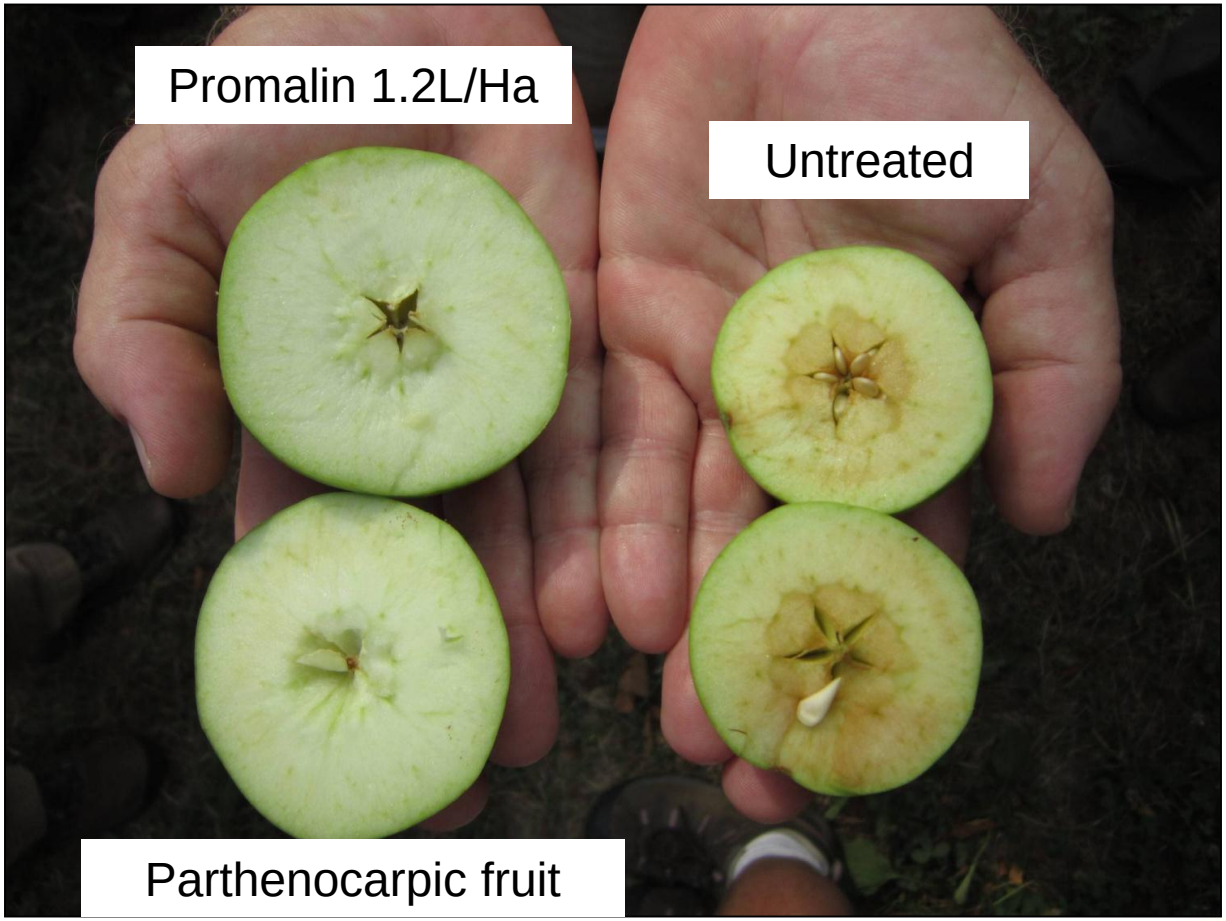
Faza rozwoju pąka	Temperatura (°C), w której uszkodzonych zostaje:	
	10% kwiatów	90% kwiatów
Nabrzmiewanie pąków	–11,9	–17,6
Rozchylanie (pękanie) okryw	–7,5	–15,7
Ukazywanie się pierwszych liści	–5,6	–11,7
Zielony pąk	–3,9	–7,9
Początek różowego pąka	–2,8	–5,9
Różowy pąk	–2,7	–4,6
Pierwsze kwiaty	–2,3	–3,9
Pełnia kwitnienia	–2,9	–4,7
Zawiązki (po kwitnieniu)	–2,3	–3,3

First Pink (Pink)	Full Pink (Open Cluster)	First Bloom (King Bloom)	Full Bloom and Post-bloom
28	28	28	28
24	25	25	25

Question: How Much Damage will -4.5°C cause at Full Bloom?

Answer: > 90% flowers dead after 30 minutes exposure

PROMALIN® FROST RESCUE TREATMENT (APPLE)



VALUE TO THE FARMER OF PROMALIN® FROST RESCUE TREATMENT (APPLE)

Table 1. Effects of gibberellin A_4 + A_7 and 6-benzyladenine (GA_{4+7} plus 6-BA) treatments after freezes during full bloom on 12 and 13 Apr. 2012 on fruit set, total yield, fruit number per tree, and mean fruit weight of 'Taylor Spur Rome'/'M.7' apple in Henderson County, NC.

Treatment[z]	Fruit set (fruit/100 clusters)	Yield (kg/tree)[z]	Yield (bu/acre)[z]	Fruit (no./tree)	Mean fruit wt (g)[z]	Crop value ($/acre)[y]
Untreated control	2.6 a[x]	11.7 a	94 a	58 a	198	1965
GA_{4+7} plus 6-BA (25 mg·L^{-1})	17.7 b	36.8 b	296 b	195 b	185	5807
GA_{4+7} plus 6-BA (50 mg·L^{-1})	14.9 b	33.9 b	273 b	185 b	182	5328
Significance[w]	**	***	***	***	NS	***

[z]1 mg·L^{-1} = 1 ppm, 1 kg = 2.2046 lb, 1 42-lb (19.1 kg) bushel (bu) per acre = 47.0757 kg·ha^{-1}, 1 g = 0.0353 oz.
[y]Calculated assuming cull fruit had a value of $0.20/lb ($0.441/kg) and fresh fruit had a value of $0.57/lb ($1.257/kg); $1/acre = $2.4711/ha.
[x]Values in a column with different letters are statistically different by Duncan's multiple range test at $P \leq 0.05$.
[w]NS, **, ***Nonsignificant or significant at $P \leq 0.01$ or 0.001, respectively, based on analysis of variance.

+11 TON / ha

+US$ 9,600/Ha

Source: McArtney et al., 2014

VALUE TO THE FARMER OF PROMALIN® FROST RESCUE TREATMENT (APPLE)

Table 4. Effect of 50 mg·L^{-1} (ppm) gibberellin A_4 + A_7 and 6-benzyladenine (GA_{4+7} plus 6-BA) sprays after a series of frost/freeze events during pink bud and full bloom on fruit set, yield, crop load, mean fruit weight, seed number per fruit, and crop value of 'Ginger Gold', 'Gala', and 'Jonagold' apple trees on 'M.9' rootstock in Geneva, NY.

Cultivar	Treatment	Fruit set (fruit/100 clusters)	Fruit (no./tree)	Yield (kg/tree)[z]	Yield (bu/acre)[z]	Crop load (% full crop)	Mean fruit wt (g)[z]	Seeds (no./fruit)	Crop value ($/acre)[y]
Ginger	Control	8.5	9	1.6	50	4	207	5.5	967
Gold	GA_{4+7} plus 6-BA	25.4	24	4.6	141	12	198	1.6	1944
	Significance[x]	NS	**	**	**		NS	**	**
Gala	Control	39.9	168	21.6	664	55	133	—	5057
	GA_{4+7} plus 6-BA	49.4	200	25.9	797	66	132	—	5988
	Significance	NS	NS	NS	NS		NS	—	NS
Jonagold	Control	18.3	20	4.8	148	11	268	—	2238
	GA_{4+7} plus 6-BA	45.6	71	17.9	550	39	257	—	8456
	Significance	**	**	**	**		NS	—	**

[z]1 kg = 2.2046 lb, 1 42-lb (19.1 kg) bushel (bu) per acre = 47.0757 kg·ha^{-1}, 1 g = 0.0353 oz.
[y]Long-term average fruit prices were assigned to the yield in each packout size to calculate a gross crop value excluding packing, storage, and sales charges; $1/acre = $2.4711/ha.
[x]NS, **Nonsignificant or significant at $P \leq 0.01$, respectively, based on analysis of variance.

+US$2,400/Ha

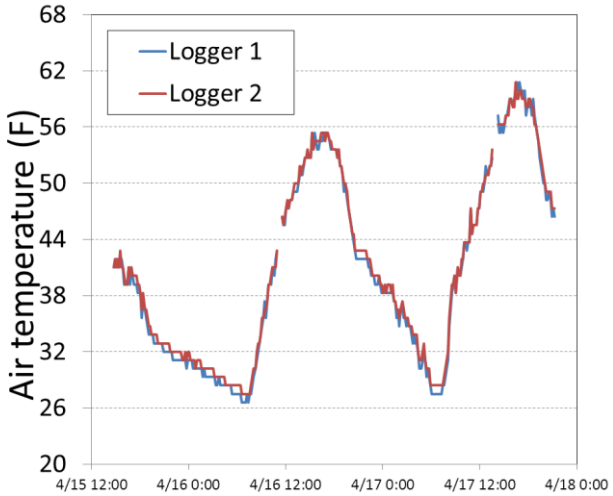
+US$15,500/Ha

Source: McArtney et al., 2014

GINGER GOLD +5 TON/Ha
GALA +7,3 TON/Ha
JONAGOLD +22 TON/Ha

PROMALIN® CAN BE SPRAYED SIX DAYS AFTER A FROST (APPLE)

Frost in 2014



Date	Frost			
	Start	Finish	Duration	Low Temp
15-Apr	20:54	8:34	9.5 hr	26.6
17-Apr	4:24	8:04	3.5 hr	27.5

Promalin Application (days after frost)	Fruit set (%)
Control	11.7 a
1 day	20.2 bc
2 days	21.9 bc
3 days	16.1 ab
5 days	18.9 bc
6 days	24.1 c
Significance	0.002

Brookfield Gala/M.7
Unpubl. data from North Carolina (2014)

Thank You