



Workshop on Plant Bioregulators for Pome and Stone Fruit Production

**Okanagan Packinghouse Fieldmans' Spring
Meeting, Kelowna
February 7, 2008**

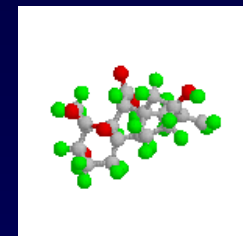
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Bioregulators Used In Tree Fruits

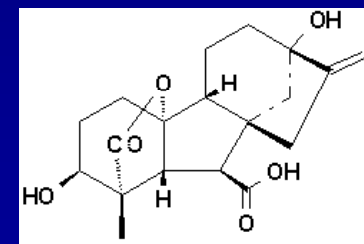


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Natural Plant Growth Substances



1. **Gibberellins** – involved in flowering, cell elongation, dormancy, delay senescence, induce maleness in dioecious flowers
2. **Auxins** – apical dominance, ripening, flowering
3. **Cytokinins** – stimulate cell division, growth of lateral buds
4. **Ethylene** - release of dormancy, stimulates leaf and fruit abscission, induction of femaleness in dioecious flowers, stimulates flower and leaf senescence, stimulates fruit ripening.
5. **Abscisic Acid** – dormancy, water stress



Reference <http://www.plant-hormones.info/index.htm>

Function	Products Available	Research Experience
1. Inhibit Flowering	GA ₃ , GA ₄ , GA ₇	Apples, Peaches, Cherries
2. Promote Flowering	Ethrel, NAA	Apple
3. Influence fruit ripening and quality	GA ₃ , GA ₄ , GA ₇ , Ethrel, Retain	Cherries, Apples, Peach
4. Fruit thinning	Carbaryl*, NAA, BA, Surfactants, Ehtrel	Apple, Peach
5. Influence ethylene synthesis	Ethrel, MCP, ReTain	Apple, Peach
6. Fruit finish	GA, Koalin Clay*	Apple,
7. Change fruit shape	Benzyl adenine (BA)	Apple
8. Reduce Preharvest drop	NAA, ReTain	Apple, Peach
9. Reduce Vegetative growth	Apogee	Apple, Peach

* - these products are not plant growth regulators

Chemical Thinning

- Principles of Chemical Thinning
 - Products used on Ontario
 - Thinning with Maxcel





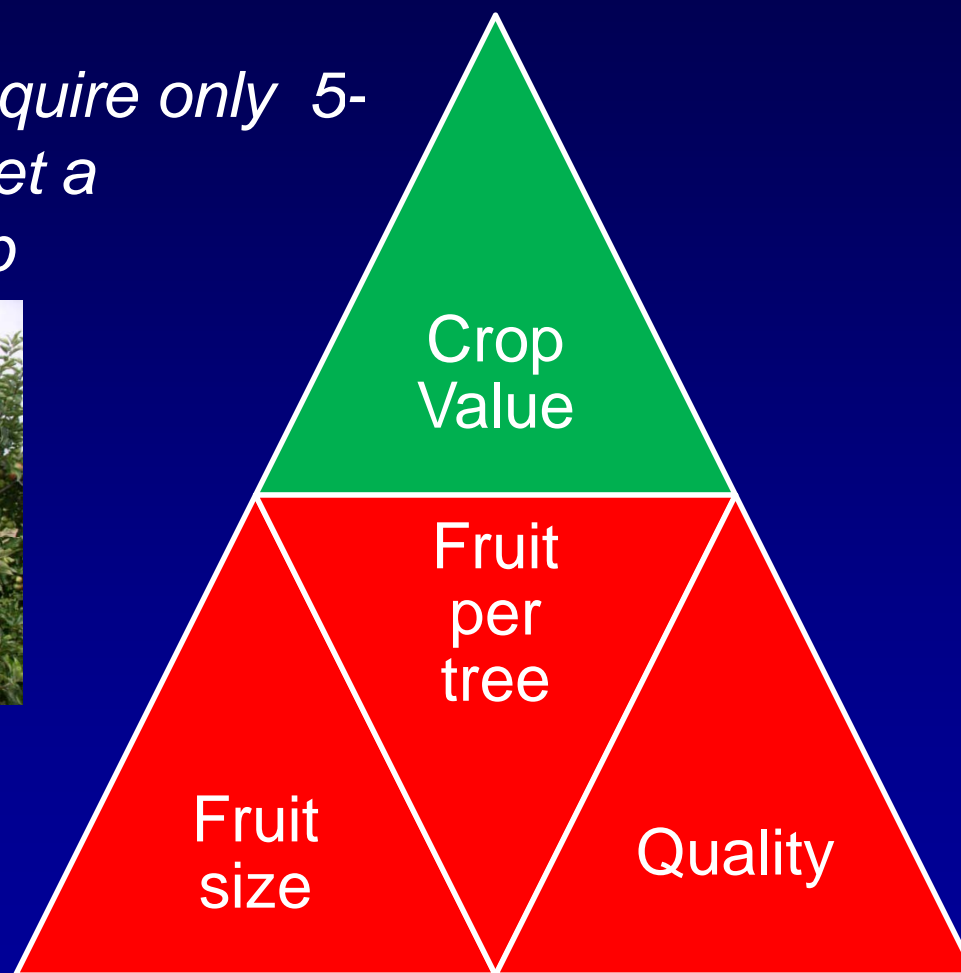
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Economics of Thinning

Fruit trees often require only 5-10% of fruit to set a commercial crop

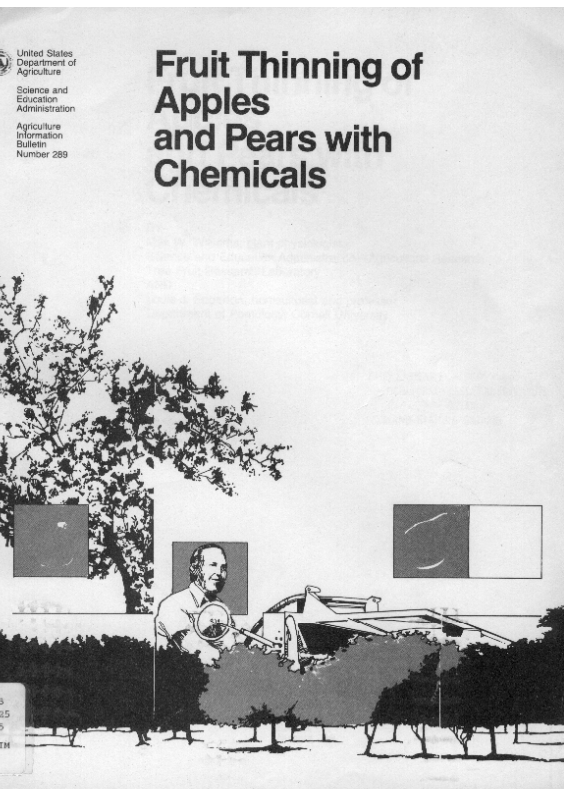


Registered Chemical Thinners for Apples in Canada

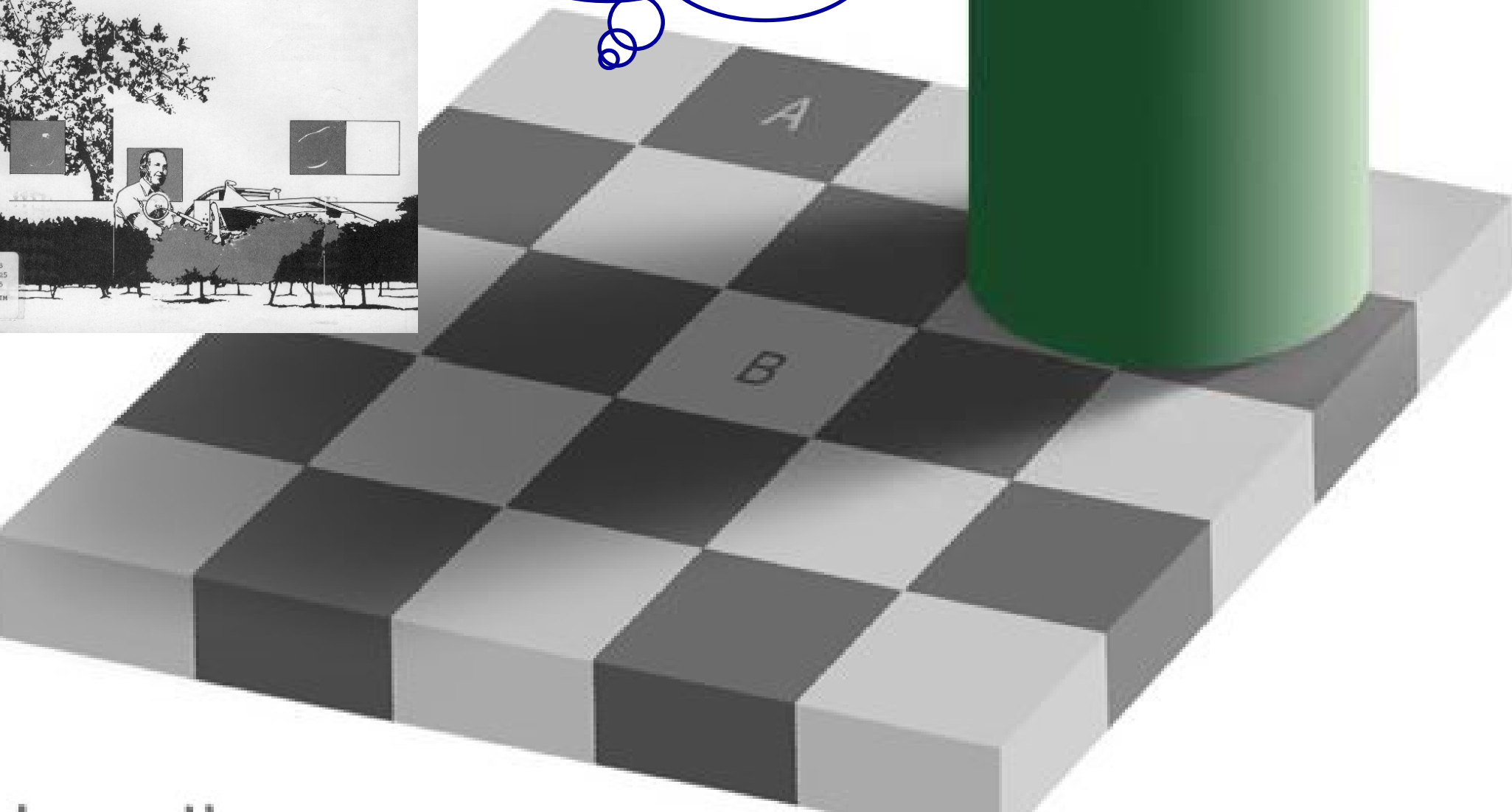


1. Fruitone N (NAA)
2. Carbaryl (Sevin XLR+)
3. 6-BA (Accel/Maxcel)





Results from
Chemical Thinning
are not always
predictable



Hand Thinning – Least Desirable



Suggested products and rates for chemical thinning various cultivars



TABLE 7-20. Suggested Rates for Chemical Thinning of Mature Apple Trees¹

Use ONE of the following:

Cultivar	NAD ppm ²	NAA ppm ²	Sevin XLR L/1,000 L	Sevin XLR +NAA ppm ² per 1,000 L water	Accel (g BA/ha) ³	Sevin XLR (L/1,000 L water) ² + Accel (g BA/ha) ³
Lodi, Melba, Quinte, Yellow Transparent	50–75	—	—	1 L + 10–15 ppm	—	—
Early McIntosh	75–100	—	—	1 L + 5–10 ppm (at petal fall)	50–75	—
Jerseymac, VistaBella, Tydeman's Red	—	5–10	1–1.5	—	—	—
Paulared	50–75	12–15	1–1.5	1 L + 10–15 ppm	75	1 L + 50
Spartan, Russets	—	10–20	1–2	1 L + 10–15 ppm	—	—
Cortland	—	5–10	—	1–2 L + 2.5–5 ppm	—	—
Ambrosia	—	—	1–1.5	—	—	—
Silken	—	—	1–1.5	—	—	—
Cameo	—	—	1	—	—	—
Non-spur McIntosh	—	5–10	1–2	—	50	—
Spur-type McIntosh	—	10–12	—	1–2 L + 2.5–5 ppm	50–75	1 L + 50
Golden Delicious, Wealthy	75–100	10–20	1–2	1 L + 5–10 ppm	75	1–2 L + 50
Golden Supreme	—	—	1	—	—	—
Goldrush	—	—	—	1 L + 10 ppm	—	—
Red Delicious	—	2–8	0.5–1.5	—	—	—
Spur-type Red Delicious	—	5–10	—	1–2 L + 5–10 ppm	—	—
Idared	—	2–8	—	—	50	—
Empire	—	7–10	1–1.5	1 L + 2.5–4 ppm	50–75	1 L + 50
Spy, Crispin (Mutsu)	—	5–10	0.5–1.5	—	—	—
Jonagold	—	—	1–1.5	—	50–75	—
Fuji	—	—	—	1–1.5 L + 10–12 ppm	—	1–2 L + 50–75
Gala	—	10–12	—	1 L + 5–10 ppm	75	1–2 L + 50
Honeycrisp	—	5	1–1.5	1 L + 2.5 ppm	—	—
Gingergold	—	7–10	1–1.5	1 L + 2.5–5 ppm	—	1 L + 50

“—” Indicates treatment recommendation not available.
¹ The above rates are suggested for trees with a settled cropping history. To chemically thin a first crop tree or trees considered to be immature is very risky.
² Sufficient water volumes must be used to thoroughly wet trees. See *Steps in Thinning* on page 130.
³ Consult Table 7-18, *Accel Rate*, on page 128, to determine the actual ppm benzyladenine (BA) being applied. Concentration of BA should be no less than 50 ppm to be effective. 1 L of Accel contains approx. 19 grams of BA.
 Note: The rates for Sevin are amounts of product. Sevin XLR is 43% active ingredient and contains 480 g or approximately 0.5 kg of carbaryl/litre. One litre of Sevin XLR is roughly equivalent to 1 kg of Sevin 50 W. For actual amounts of NAD and NAA refer to the label of the product being used.

Cultivar Sensitivity to Chemical Thinners

Easy to Thin

- Braeburn
- Crispin
- Ginger Gold
- Idared
- Jersey mac
- Jonagold
- Jonathan
- Red Del
- Ambrosia
- Honeycrisp



Intermediate to Thin

- Cortland
- Empire
- Jonamac
- McIntosh
- Nothern Spy
- Gala

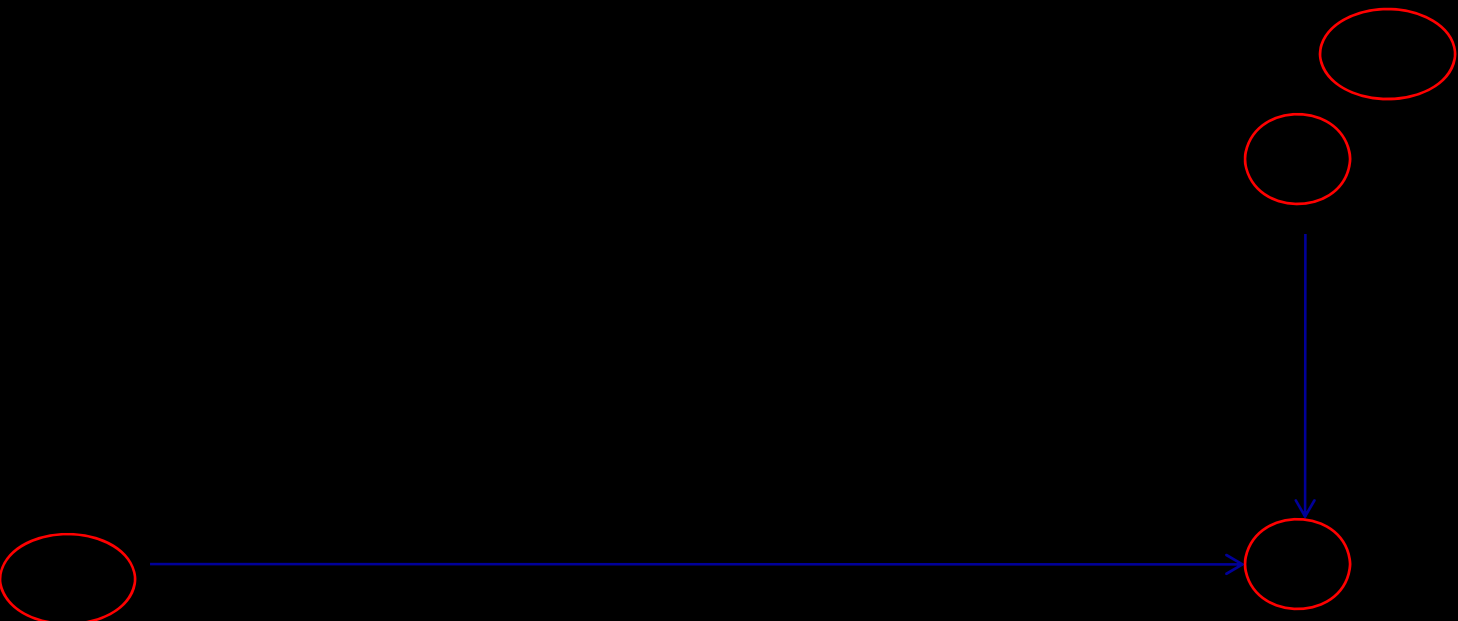
Difficult to Thin

- Fuji
- Golden Delicious
- Lodi
- Rome
- Spartan
- Spur Red Delicious
- Wealthy

Thinning Products and Rates of Activity



	NAA (ppm)	Accel (ppm)	Sevin (L/ha)	Accel + Sevin (ppm, L/ha)	NAA+Sevin (ppm, L/ha)
Mild	5	50	1.0	-	
Moderate	10	75	1.5	50, 0.5	5, 0.5
Aggressive	15	-	-	75, 1.0	10-15, 1.0



Timing

- ✓ NAD - Amidthin (King Bloom petal fall)
 - ✓ Accel 8-12 mm
 - ✓ Sevin XLR - Petal Fall - 21 Days after Full Bloom
 - ✓ NAA - Bloom - 12 mm (later applications tend to reduce fruit size)
-
- ✓ apply prior to warming trends as increasing temperatures promote the thinning response
 - ✓ Bright sunny days following applications tend to decrease the thinning response
 - ✓ Higher night temperatures increase the thinning response



Water Volume of water and Spray Distribution

- Apply sufficient water to obtain good foliage and fruitlet coverage.
- Do not concentrate beyond 2X or 1000 litres per hectare
- Apply 65-90 % of water volume to the top of the tree canopy (except super spindle)



Blossom Thinning

Not widely adopted in Ontario. ATS works but often causes phytotoxicity



Advances in Blossom Products

- Ammonium thiosulphate (ATS) is effective, but remains unregistered, not certified organic
- Other natural compounds and surfactants being tested
- Likely adopted commercially in combination with a fruitlet thinning program
- Phytotoxicity and risk of frost major barriers



Thinning Gala with Maxcel

Maxcel

- Adequately thinned
- Improved fruit size beyond effect of hand thinning
- Worked effectively with Sevin

Table 5. Effect of Maxcell on yield, fruit number and fruit size of 'Gala'/M.26 apple trees. University of Guelph, Simcoe, Ontario, 2004.

Treatment	Rate (mg/L)	Yield (kg.tree ⁻¹)	Total number fruit per tree	Mean fruit weight (g)	Crop density (#.cm ⁻²)
Untreated Control		36.0	229	158.6	7.1
Hand thinned control		30.5	167	182.3	5.9
Maxcel	75	33.6	183	184.9	5.5
Maxcel	100	23.8	134	178.7	4.6
Maxcel + Carbaryl ^x	75	23.7	127	188.2	4.1
NAA + Carbaryl ^x	5	23.3	120	198.1	4.3
significance ^z		***	***	***	***
LSD (P=0.05)		3.85	23.7	12.81	1.15
P value		<0.0001	<0.0001	<0.0001	<0.0001

^x Carbaryl XLR Plus applied at 750 ppm

^z ns, ***, **, *, indicates non significance and statistical significance at P=0.001, P=0.01, and P=0.05, respectively

Thinning Gala with MaxCel (BA)

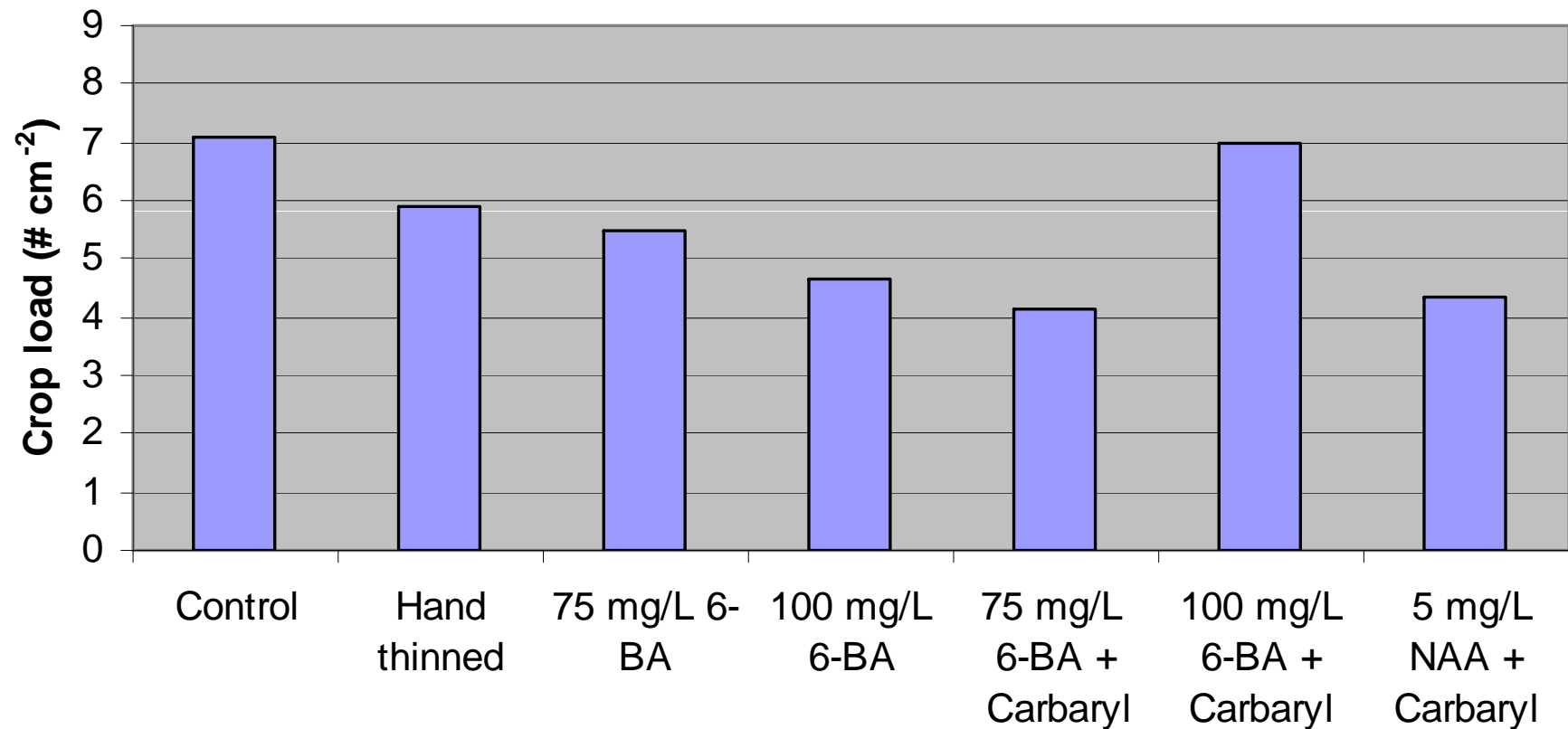
- Adequately thinned
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Table 3. Effect of Maxcel and Carbaryl on yield, fruit number and fruit size on 10-yr-old 'Royal Gala'/Bud.9 apple trees. University of Guelph, Simcoe, Ontario, 2007.

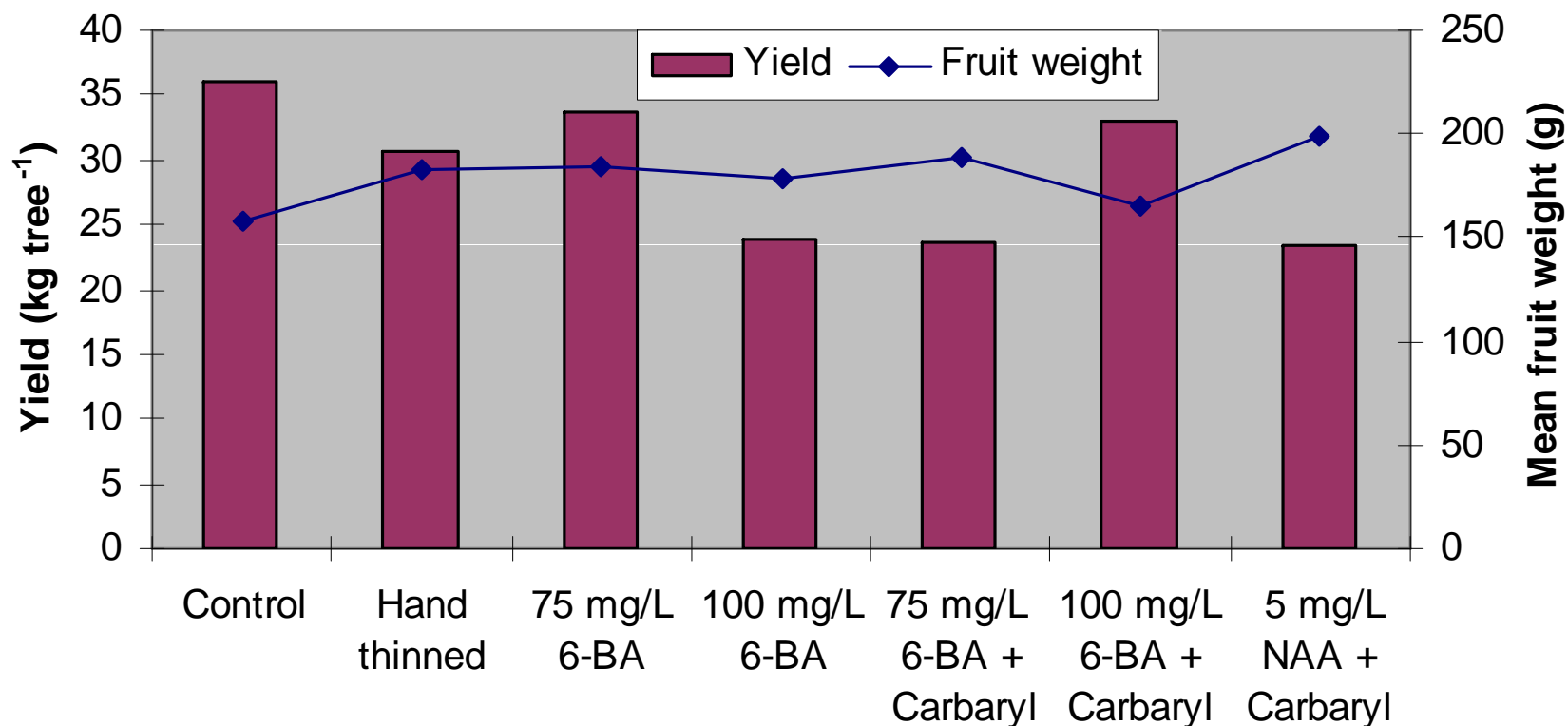
Treatment	Rate (mg/L)	TCSA fall 2007 (cm ²)	Yield (kg.tree ⁻¹)	Yield efficiency (kg.cm ⁻²)	Total number fruit per tree	Mean fruit weight (g)	Crop density (#.cm ⁻²)
Untreated Control		41.2	25.0	0.61	187.5	137.4	4.3
Hand thinned control (every other spur)		43.0	20.7	0.49	131.9	160.3	3.2
Maxcel	75	37.4	23.8	0.65	186.9	137.9	5.3
Maxcel	100	45.4	28.9	0.65	186.8	156.1	4.2
Maxcel + Carbaryl	75,750	41.3	15.9	0.40	94.3	175.6	2.4
Maxcel + Carbaryl	100,750	40.3	14.6	0.45	81.1	188.1	2.5
Exilis	75	46.0	33.0	0.72	229.8	146.6	5.0
Exilis	100	38.6	24.4	0.66	175.9	144.3	4.8
Exilis + Carbaryl	75, 1000	43.9	16.9	0.36	107.4	168.3	2.4
Exilis + Carbaryl	100, 1000	41.3	13.6	0.32	87.9	174.2	2.1
significance ^z		ns	**	*	***	***	**
LSD (P=0.05)		7.74	9.83	0.25	75.42	23.25	1.98
P value		0.4294	0.0012	0.0155	0.0004	<0.0001	0.0030

^z ns, ***, **, *, indicates non significance and statistical significance at P=0.001, P=0.01, and P=0.05, respectively

Effect of 6-BA and Carbaryl on Gala Crop Load

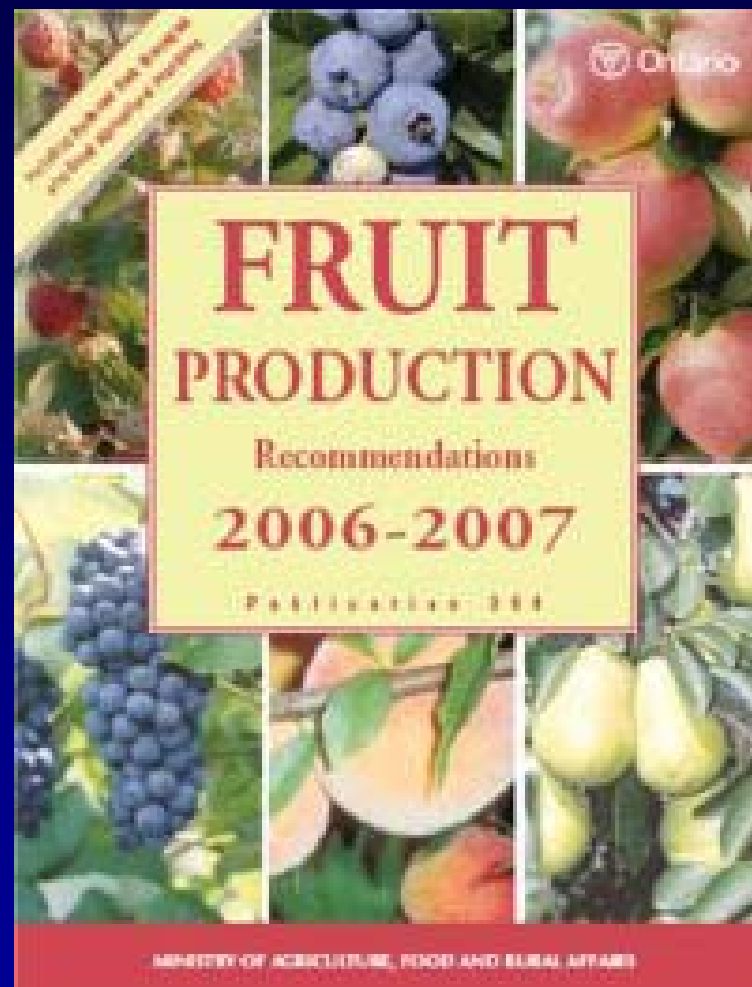


Effect of 6-BA and Carbaryl on Gala Yield and Fruit Size



Thinning Resources

- Updated Thinning Information
- Cultivar Sensitivity
- Table of Contents



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* - these products are not plant growth regulators

Gibberellin-Based Growth Regulators

Products: Activol/Progibb and Promalin

1. Apple - Reduce russeting (G. Delicious)
 - Mixture of GA_{4+7}
 - Improve fruit quality
2. Improve apple size and shape
 - used on Red Delicious for typiness
 - effective on Royal Gala



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Ethylene Related Bioregulators

Ethephon, Aminoethoxyvinylglycine

Ethephon (Ethrel)

- liquid compound that dispenses C_2H_2
- accelerate ripening at harvest (use cautiously)
- Can use on non-bearing trees to enhance flowering the following year



Gibberellic Acid for Sweet Cherries

- preharvest sprays extend harvest season of cherries
- larger firmer fruit, less bruising (pitting) in storage
- used widely in industry

Objectives

To determine the benefits of GA₃ on:

1. Fruit size
2. Fruit firmness
3. Fruit maturity (harvest)
4. Rain-cracking



Timing

Jun 12



Jun 20



Secondary objectives were to investigate:

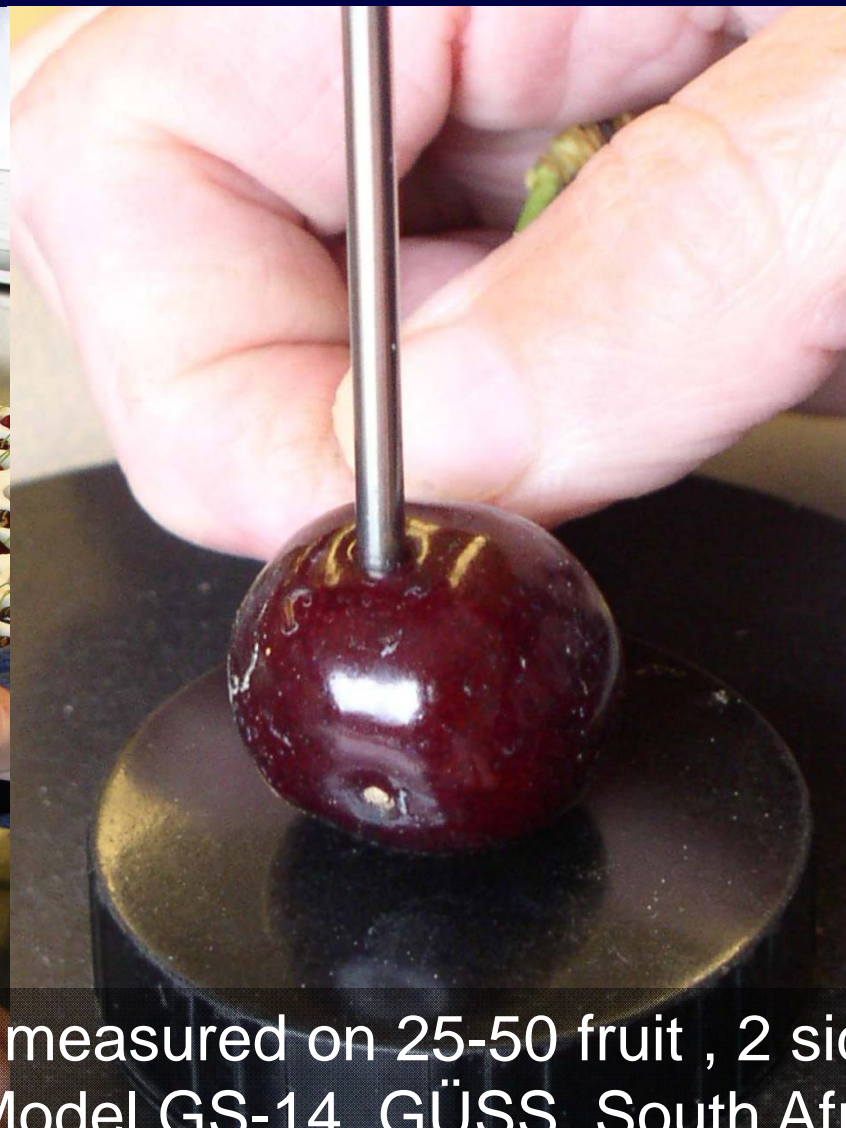
1. Application timing
2. Product formulation (Progibb 4 and Progibb 40%)

Methodology

- A series of experiments conducted (2002-2007)
- Rates: 20-80 mg/L GA₃ (Progibb 40%)
- Air blast applications
- Single trees
- Fruit quality measurements included: fruit firmness, surface colour, soluble solids, fruit weight, and rain-induced fruit cracking

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- ◆ Flesh firmness was measured on 25-50 fruit , 2 sides
- ◆ Fruit texture Analyzer Model GS-14, GÜSS, South Africa
- ◆ 3 mm probe, depth of 1mm (did not penetrate skin)

Summary of GA effects



- Progibb has consistently increased fruit firmness and had a slight effect on fruit colour (harvest)
- Inconsistent treatment effects on fruit weight, and rain cracking
- Progibb 40% was more effective than Progibb 4% in enhancing fruit firmness and size

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PBRs to Enhance Flowering

Ethrel (Ethephon) 150 mg/l
NAA (Fruitone-N) – 5 mg/l
Have been used
independently at low
concentrations during
June-July to enhance
return bloom the following
season



Flower Induction & Development

Induction

- 2-6 weeks after full bloom

Development

- 6 wks to bloom following year
- Most floral parts are present by harvest



Ethrel on Non Bearing Trees

- Ethrel sprays can successfully be used to enhance the return bloom of non-bearing
- Higher rates can be used since there is no concern of excessive fruit thinning.
- Single applications (early July) between 1000-1500 mg·litre⁻¹ Ethrel are as effective as split applications at 50% of these rates. A reduction in tree growth can be expected in the season of application.

Ethrel on Bearing Trees

- Lower rates of 150 or 300 mg·litre⁻¹ significantly improved the return bloom of 'Empire' and 'Fuji', respectively.
- At least two applications (early July, 1 wk apart) are required to obtain this benefit.
- Three sprays of NAA at 4 mg·litre⁻¹ was effective for enhancing the return bloom of 'Empire' but not 'Fuji' or 'Jonagold'.

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Why stone fruit trees

- Produce an abundance of flowers, of which ~10% are required to produce a full crop
- to maximize crop value by optimizing fruit size and quality
- maintain tree growth and structure



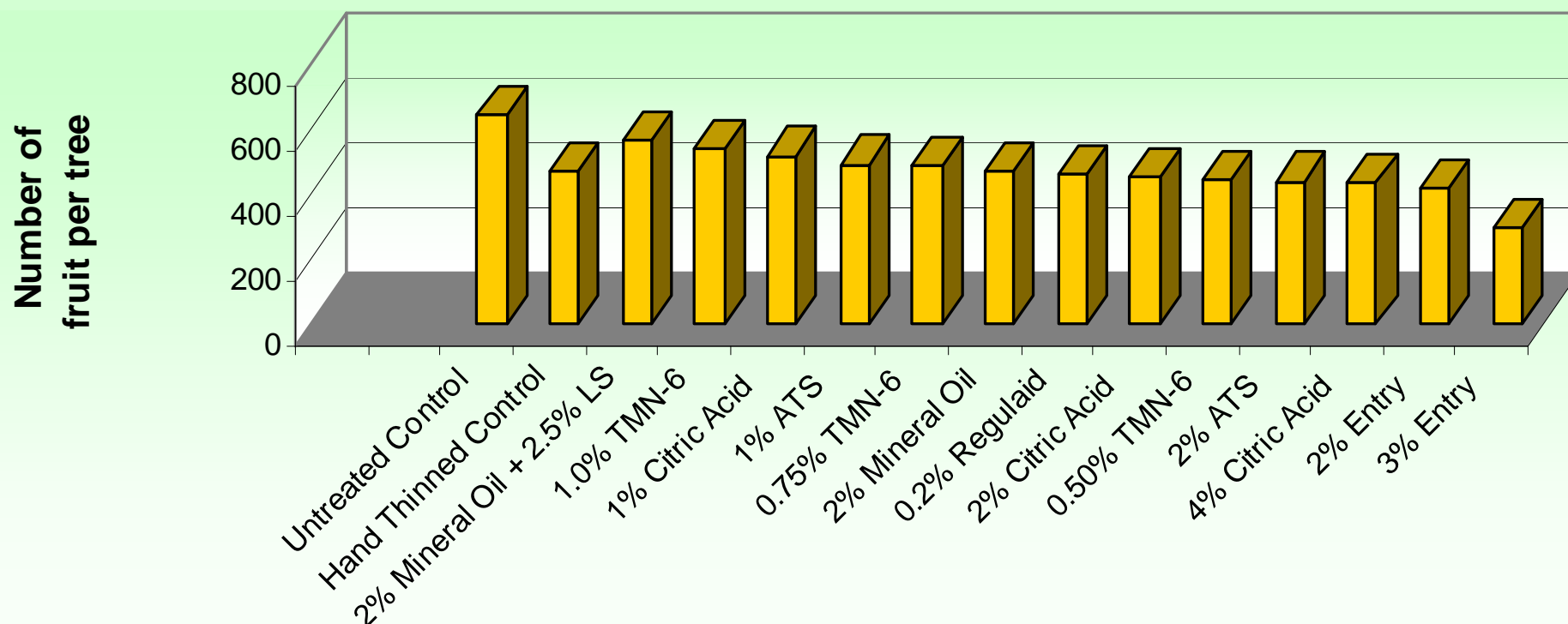
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Most Promising Methods to 'Thin' Peaches

- Blossom thinning (TMN-6, Entry)
- Fruitlet thinning (Ehtrel)
- Flower inhibition (GA_3)
- Fall applications of ethephon (delays bloom and reduces flowering)

Blossom Thinning Results look promising...

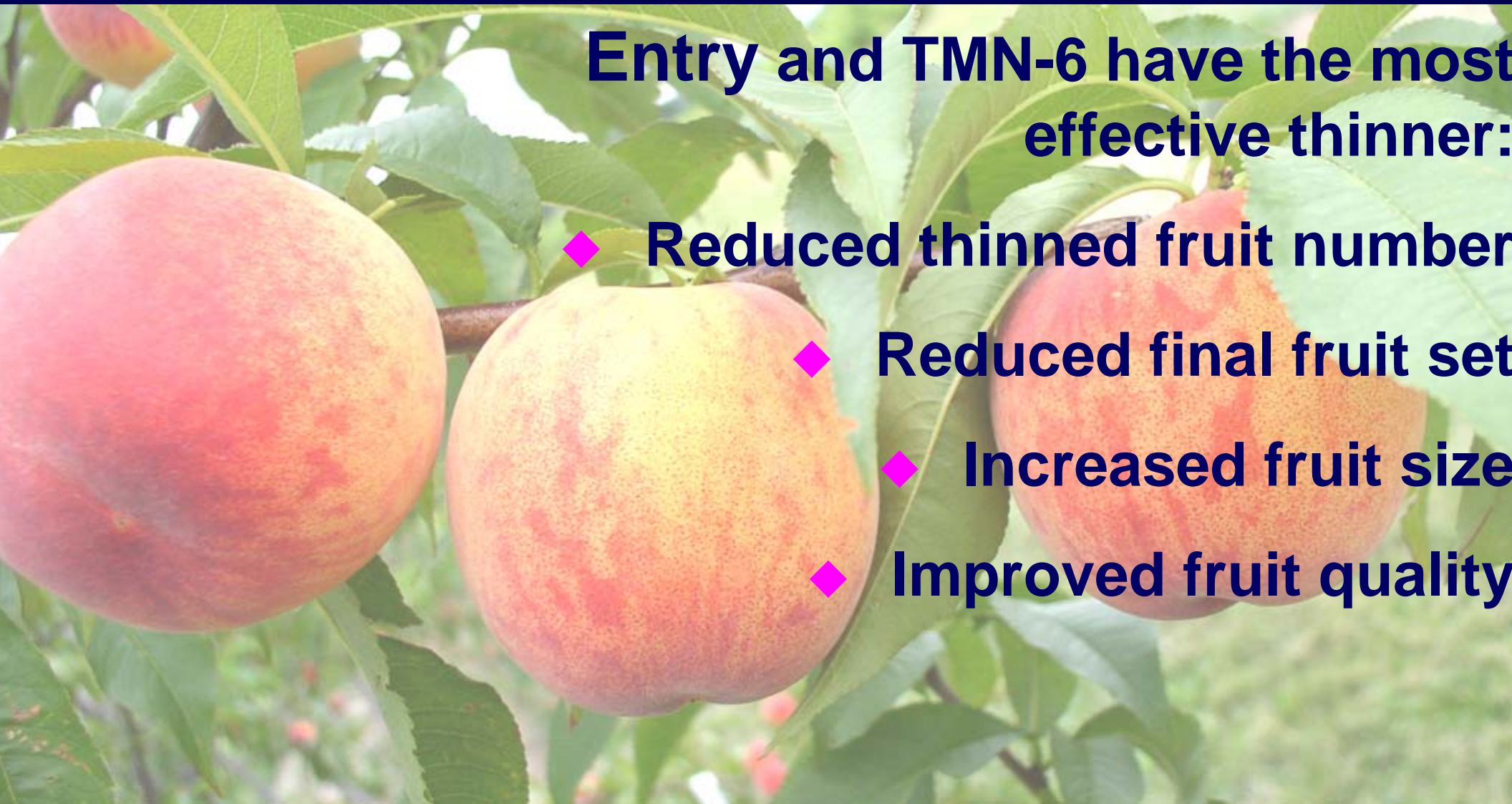
Effect of various blossom thinners on number of fruit per tree of 'Harrow Diamond' peaches, 2004



Summary of Peach Blossom Thinning Research

Entry and TMN-6 have the most effective thinner:

- ◆ **Reduced thinned fruit number**
- ◆ **Reduced final fruit set**
- ◆ **Increased fruit size**
- ◆ **Improved fruit quality**



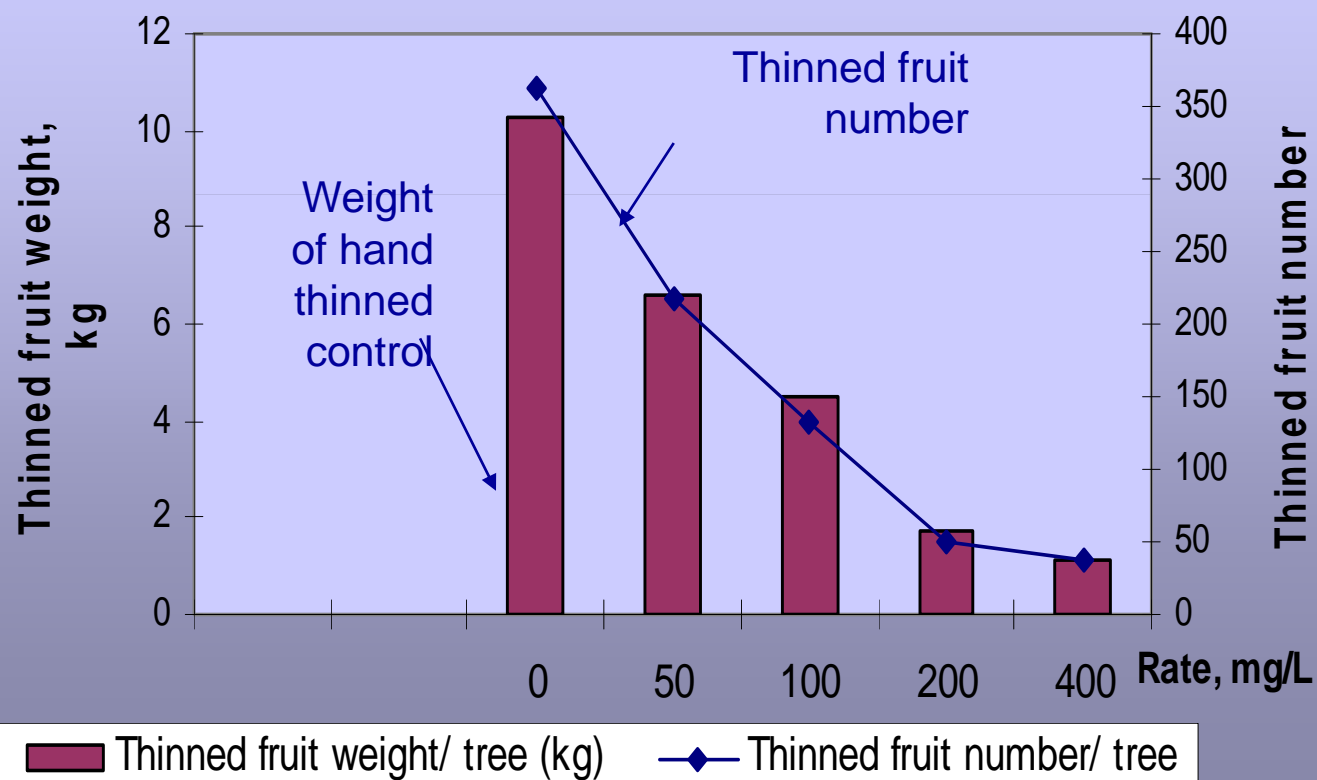
Flower Inhibitors

- GA_3 - stone fruit
- GA_{4+7} - pome fruit
- Concept: reduce or prevent flower initiation, thereby minimizing the requirement for chemical and hand thinning



Effect of GA Rate on Thinned Fruit Weight and Number

Fig. 5 Effect of GA concentration on thinned fruit weight and number per tree of "Red Haven" peach trees, 2003



- GA significantly reduced the amount of hand thinning requirements (30% reduction for GA at 50 ppm)



Untreated
control

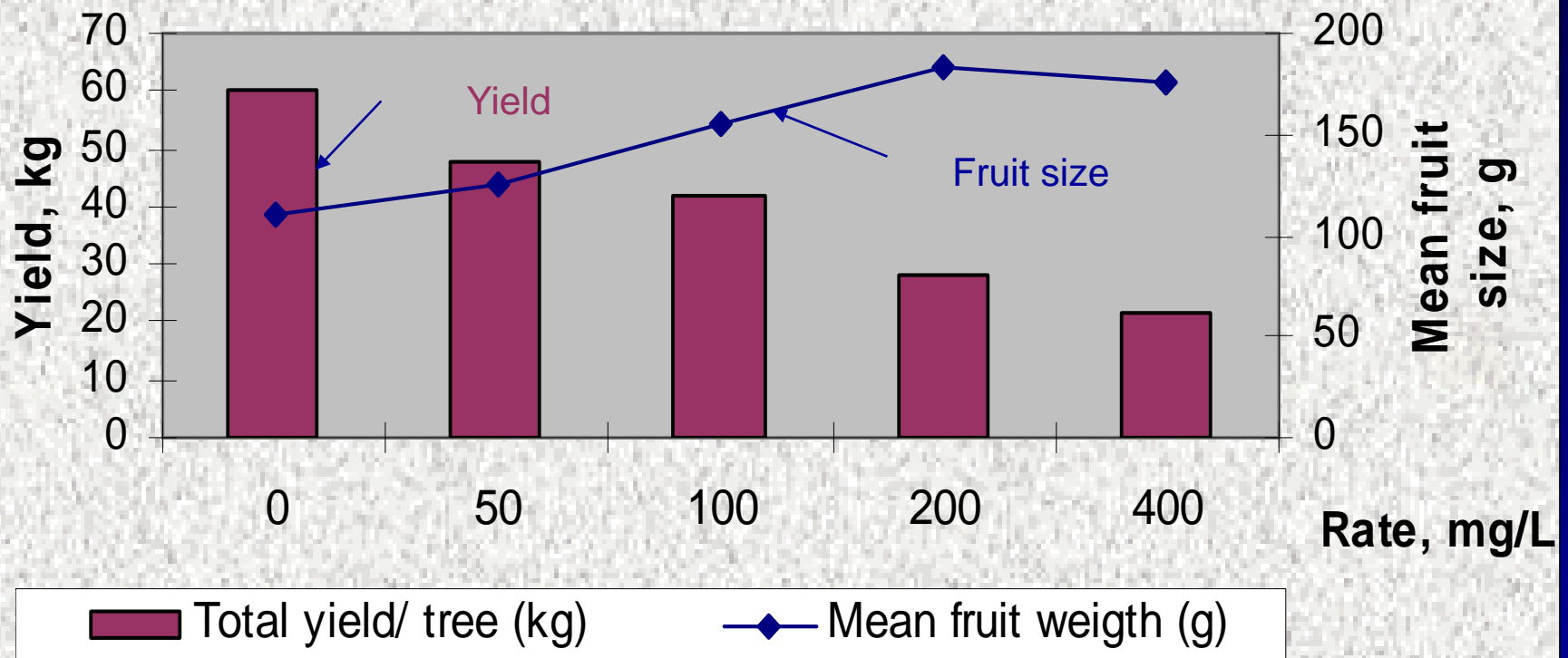
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GA at
100 ppm

Fig. 7 Effect of GA rate on crop load and fruit size of "Red Haven" peach trees, 2003



- Significant GA rate and timing effect on crop load reduction;
- Increased fruit size

Summary - Gibberellic Acid Treatments

- Did not affect current season crop density, yield, or fruit size;
 - Improved fruit quality;
- Reduced the need of hand thinning;
 - Increased fruit size;
- Improved colour and SSC;
 - Advanced maturity;
- Increased vegetative growth



Future of Plant Bioregulators in Tree Fruit

- Likely more specific on plant processes and environmentally safe compounds
- Growers need fruit thinners for stone fruit (blossom and/or fruitlet)
- Expansion in the use of GA as a flower inhibitor
- Absciscic acid and benefits for reducing water stress
- Need to clearly demonstrate the cost:benefit of PBRs

Unanswered Questions

- Can cherries be chemically thinned (to improved fruit size)?
- Is there are PBR to regulate the vegetative growth of peaches and cherries?
- Absciscic acid is the only plant hormone that has not been used commercially. Can ABA be used to reduced drought stress?