Review of Early Thinning Practices for Apples

Tom Kon and Jim Schupp

NC STATE UNIVERSITY

CLEMSON UNIVERSITY

UNIVERSITY OF GEORGIA

Outline

I. Thinning apples early: Intro

II. Early thinning strategies
   I. Pruning
   II. Chemical blossom thinners
   III. Mechanical blossom thinners

III. Summary & Future Outlook

Why do we thin?

Fruit Size
Fruit Quality
Annual Bearing

Why do we thin?

- 2 – 12 % of apple blossoms are required to set a full crop…


Typical application timings of eastern thinning programs

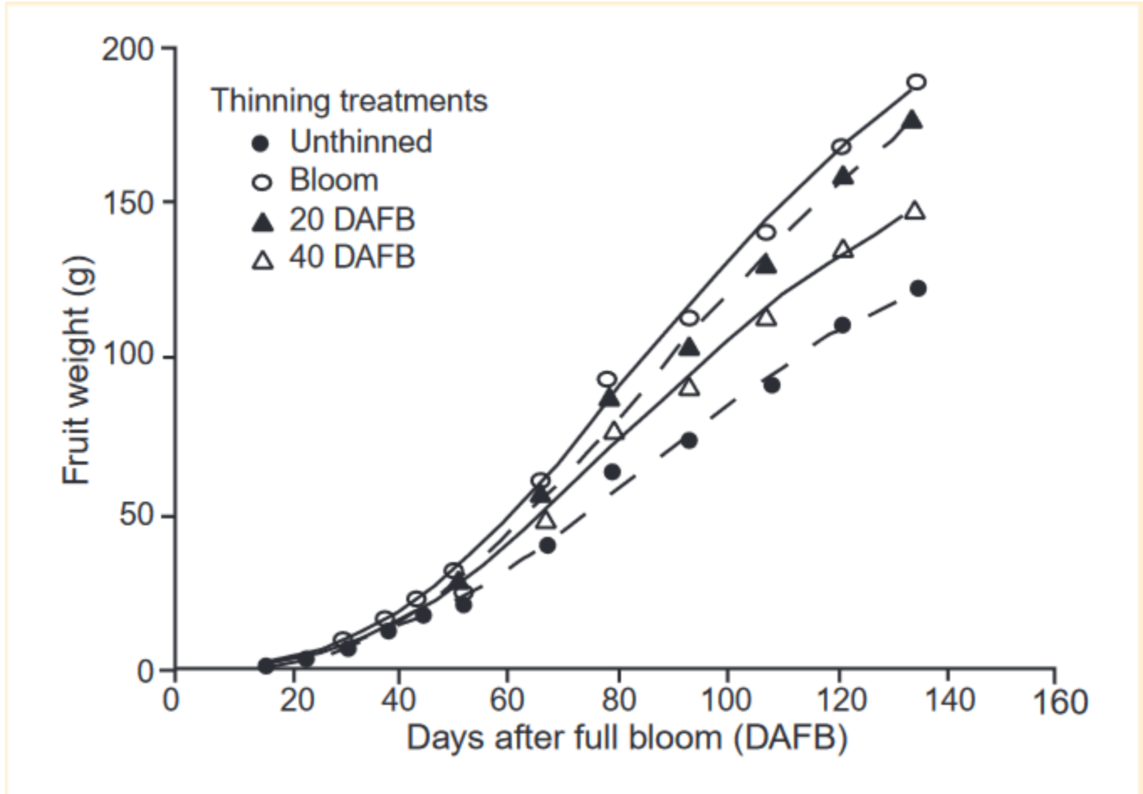
5-7 mm	8-16 mm	17-24 mm	30 mm +
Petal Fall	**Post-bloom**	**Rescue**	**Hand Thinning**



Are we missing an opportunity?

Pre-bloom → Bloom → Petal Fall → Post-bloom → Rescue → Hand Thinning

- Fruit size potential: determined by cell #
- Compared to later timings early thinning can:
  - Increase fruit size
  - Improve return bloom
- Small fruited, biennial, and/or high value



Whole Foods Market Responsibly Grown

Prohibited and Restricted Pesticides Policy for Produce and Flowers

This updated version of the Policy goes into effect January 1, 2017

WFM CATEGORY 1B: PROHIBITED The following active ingredients are PROHIBITED without exception regardless of product origin for Responsibly Grown ratings			
Registered for food use by US EPA			
▪ 1,3-dichloropropene	▪ diazinon*	▪ malathion*	▪ phorate*
▪ 2,4-D	▪ dimethoate*	▪ methiocarb**	▪ phosmet*
▪ acephate*	▪ endosulfan	▪ methomyl**	▪ propargite
▪ aldicarb**	▪ EPTC	▪ methyl bromide	▪ terbufos*
▪ atrazine	▪ ethoprop*	▪ naled*	▪ thiabendazole
▪ carbaryl**	▪ formetanate hydrochloride**	▪ oxamyl**	▪ thiophanate-methyl
▪ chlorpyrifos	▪ imazalil	▪ oxydemeton methyl*	

"Whole Foods Market prohibits the use of several additional high-risk pesticides including all organophosphate and **N-methyl carbamate** pesticides. These pesticides may be allowed by US EPA on product grown in the US, but research indicates they can impair the neurological development of children born of mothers exposed in their diets, or through working in agriculture and living in nearby communities. **These active ingredients are broadly toxic to many beneficial organisms including many pollinators**."

Outline

I. Thinning apples early: Intro

II. Early thinning strategies

  I. Pruning

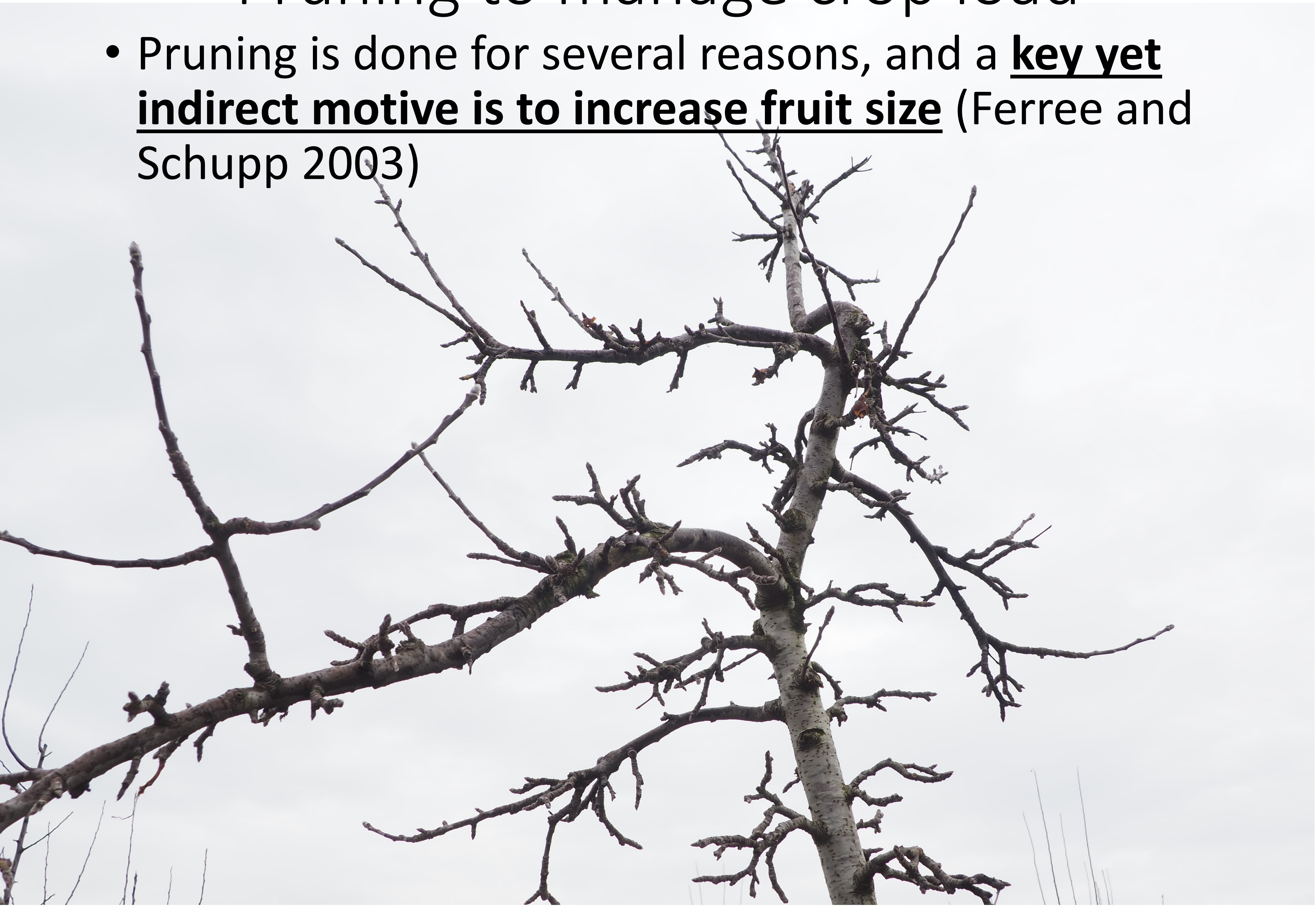
  II. Chemical blossom thinners

  III. Mechanical blossom thinners

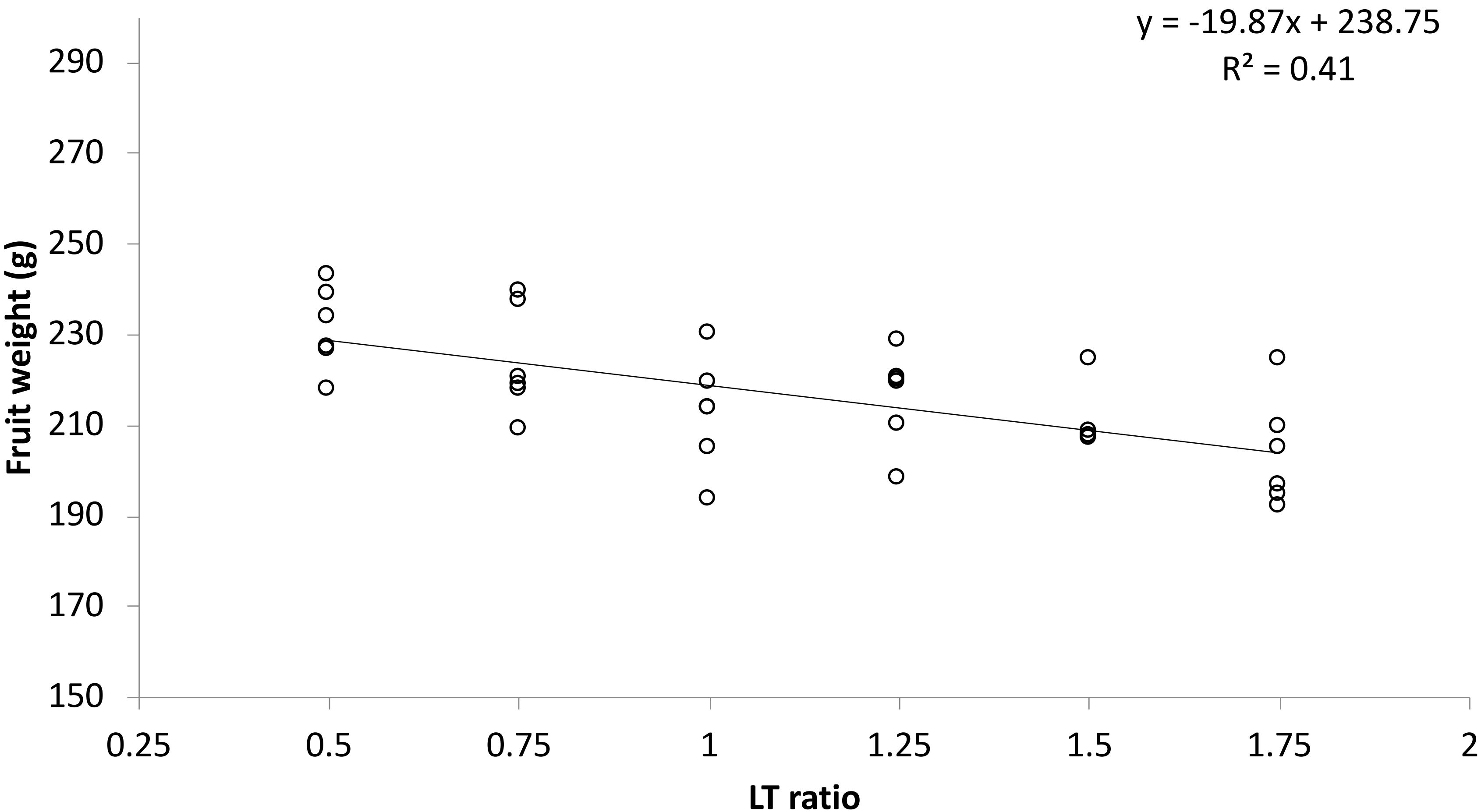
III. Summary & Future Outlook

Pruning to manage crop load

- Pruning is done for several reasons, and a **<u>key yet indirect motive is to increase fruit size</u>** (Ferree and Schupp 2003)



Relationship between pruning severity and fruit weight (2013-2016)



Slide courtesy of Jim Schupp: Schupp et al. 2013

Spur pruning (artificial spur extinction; ASE) to reduce crop potential

Kon and Schupp. 2018. Apple crop load management with special focus on early thinning strategies: a USA perspective. Hort. Rev. 46:255-298

Table 6.1 Summary of recent spur-pruning (extinction) studies.

Author(s)	Cultivar(s)	Floral bud densities evaluated	Training system	Hand-thinned	Laterals modified	Increased fruit set/ spur	Reduced crop load	Increased fruit size	Reduced yield	Increased return bloom	Increased shoot growth
Breen et al. 2014	'Gala'	3 and 5 buds cm^{-2} LCA	Tall spindle	Yes[a]	Yes	Yes	NA[b]	NA	NA	NA	NA
Breen et al. 2015	'Royal Gala'	2, 4, and 6 buds cm^{-2} LCA	Tall spindle	Yes	Yes	Yes	No	Yes	No	NA	NA
Lauri et al. 2004	'Galaxy'	2 and 4 buds cm^{-2} LCA	Centrifugal	Yes	Yes	NA	NA	Yes	No	No	Yes
Nichols et al. 2011	'Honeycrisp'	~40, 60, and 80 buds m^{-3} canopy volume	Central leader and vertical axis	NA	No	NA	Yes	Yes	NA	NA	Yes[c]
Robinson et al. 2014a	'Gala' and 'Honeycrisp'	~1/3 of spurs removed	Tall spindle	No	No	No	2 of 3 studies	Yes	2 of 3 studies	No	NA
Tabing et al. 2016	'Kalei'	3,4, 5, and 6 buds cm^{-2}	Vertical axis	Yes	Yes	Yes	NA	Yes	Yes	NA	NA
Tustin et al. 2012	'Scifresh'	2–6 buds cm^{-2} LCA	Tall spindle	Yes	Yes	Yes	NA	NA	NA	Yes, in off year	NA
van Hooijdonk et al. 2014	'Scilate'	5 buds cm^{-2} LCA	Tall spindle	Yes	Yes	Yes	1 of 3 years	2 of 3 years	1 of 3 years	2 of 3 years	Yes

- In most trials fruit size increased (7/8), however:
  - Fruit set/spur was increased (5/6)
  - Mixed response on crop load (4/8), return bloom (3/6)
- Becky Weipz (Wed. 11 AM): "Research and Applications of Artificial Spur Extinction in Pennsylvania Orchards"

Chemical Blossom Thinners

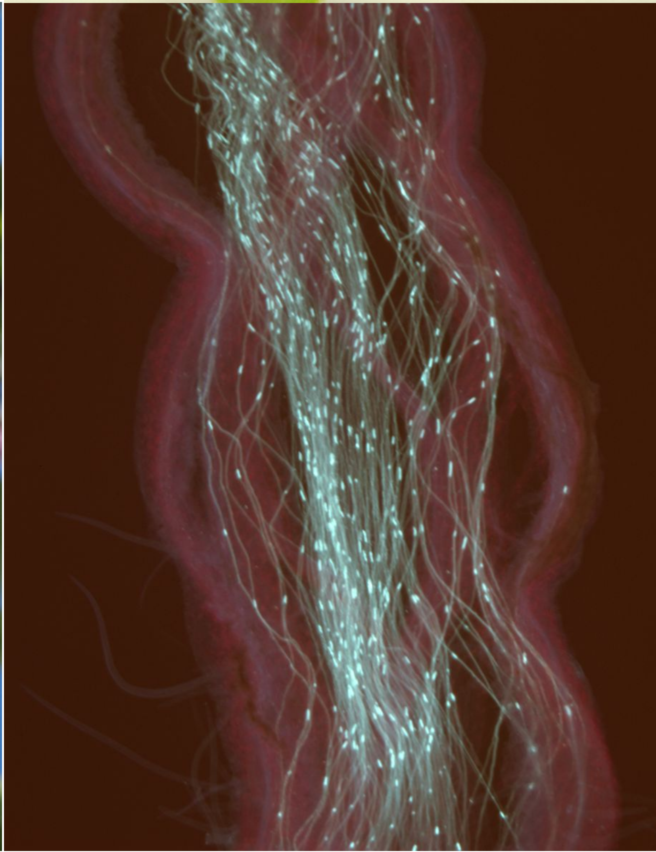
Chemical Bloom Thinning: Concerns in the eastern U.S.

- **Lack of registered products**
- Risk of frost
- Uncertainty of initial fruit set
- Fruit injury & phytotoxicity
- **Inconsistent results**

- There has been a considerable research effort to develop new apple blossom thinners
- Several thinners have shown promising results
- Lack registered products*

Bloom Thinner Development

- In the 1980's, several compounds were evaluated as bloom thinners on peach (Byers et al.)
- Adjuvants, Essential Oils & Extracts, Fertilizers & Salts, Fungicides, PGR's, Herbicides & Acids, Films/Coatings



Over 150 compounds were screened/evaluated

(Kon and Schupp, 2018)

Adjuvants	Essential Oils and Extracts	Fertilizers and salts	Fungicides
Armothin	Biochicol 020 PC	ammonium sulfate	Agri-mycin 17
Basic-H	Bioczos and garlic soap	ammonium thiosulfate (ATS)	Armicarb
biodiesel	bioneem; Rimulgan	Azolon	benomyl
Biofilm	black pepper oil	calcium chloride	binapacryl
Canola oil	camphor oil	calcium nitrate	bupirimate
Codacide	catechin	cor-clear	captan
Dehydol TA 29	cedarwood oil	ferric sulfate	copper sulfate
Dehydol TA 5	cinnamon oil	Kasil-6 (potassium silicate)	Dikar 76
dormant/mineral oil	clove oil	mono-ammonium phosphate (MAP)	dinocap
fish emulsion	coumarin	NC99	dithianon
fish oil	cypress oil	potassium bisulfate	Ecocarb
mineral oil	eucalyptus oil	potassium iodide	EDTA
Olejan 85 EC; Telmion	eugenol	potassium meta-bisulfate	Elgetol
olive oil	fir needle oil	potassium sulfate	Funginex
PCC711	ginger oil	potassium thiosulfate (KTS)	Kaligreen
PCC713	Goemar	sodium chloride	Kresoxim-methyl
PCC715	grapefuit oil	sodium hydroxide	lime sulfur
Silwet 408	lavender oil	sodium meta-bisulfate	mancozeb
Silwett (L-77)	lemon oil	sodium nitrate	Nova 40W
soya oil	linseed oil	Stopit	Polyram 80W
sunflower oil	Matran EC	urea	Regalia
Tergitol; TMN-6; Dupont WK	menthol		Remedy
Triton B-1956; Latron B-1956	molasses	**Films and coatings**	sodium bicarbonate
Triton X-100	pine needle oil	Anti-Stress	sulfur
Triton X-114	Proflo oil	black oil	Topsin-M 70W
Tween 20	seaweed extract	BrilliantSchwarz (E151)	
vegetable oil emulsion	spruce oil	dextrin	**Herbicides and Acids**
YI-1066	tangerine oil	Masbrane (Gao-Zhi-Mo)	acetic acid
Plant Growth Regulators	tea tree oil	milk	cinnamic acid
(+)-8'-acetylene abscisic acid	thistle oil	natural lecithin polymeric film	citric acid
4-CPA	thymol	Nufilm	endothall
CPPU	vinasse	Nurti-Save	glutamic acid
dichlorprop	walnut leaves - tea	Olejan 85 EC	hydrogen peroxide
Dormex	witch hazel	PEG-1000	oxalic acid
ethephon	ylang ylang III oil	potato starch	salicylic acid
ethychlozate		Safer-Soap	sodium hypochlorite
MCPB-ethyl		Surround	Thinex (MYX4801)
methyl jasmonate		wheaten flour	Wilthin
NAA			
NAD			
NSK-905			
promalin			
s-abscisic acid (ABA)			
thidiazuron			

Current blossom thinners

- Number of commercially available products is limited
  - calcium polysulfide (lime sulfur, 1860's)
  - ammonium thiosulfate (1960's) **Not designated as a thinner (FIFRA)**
  - ~~endothal (1960's)~~
  - naphthaleneacetamide (NAD; Amid-Thin W, 1930's)

- Improving consistency of existing blossom thinners and/or developing alternative crop load management strategies remains a research priority

WTFRC CHEMICAL THINNING TRIALS

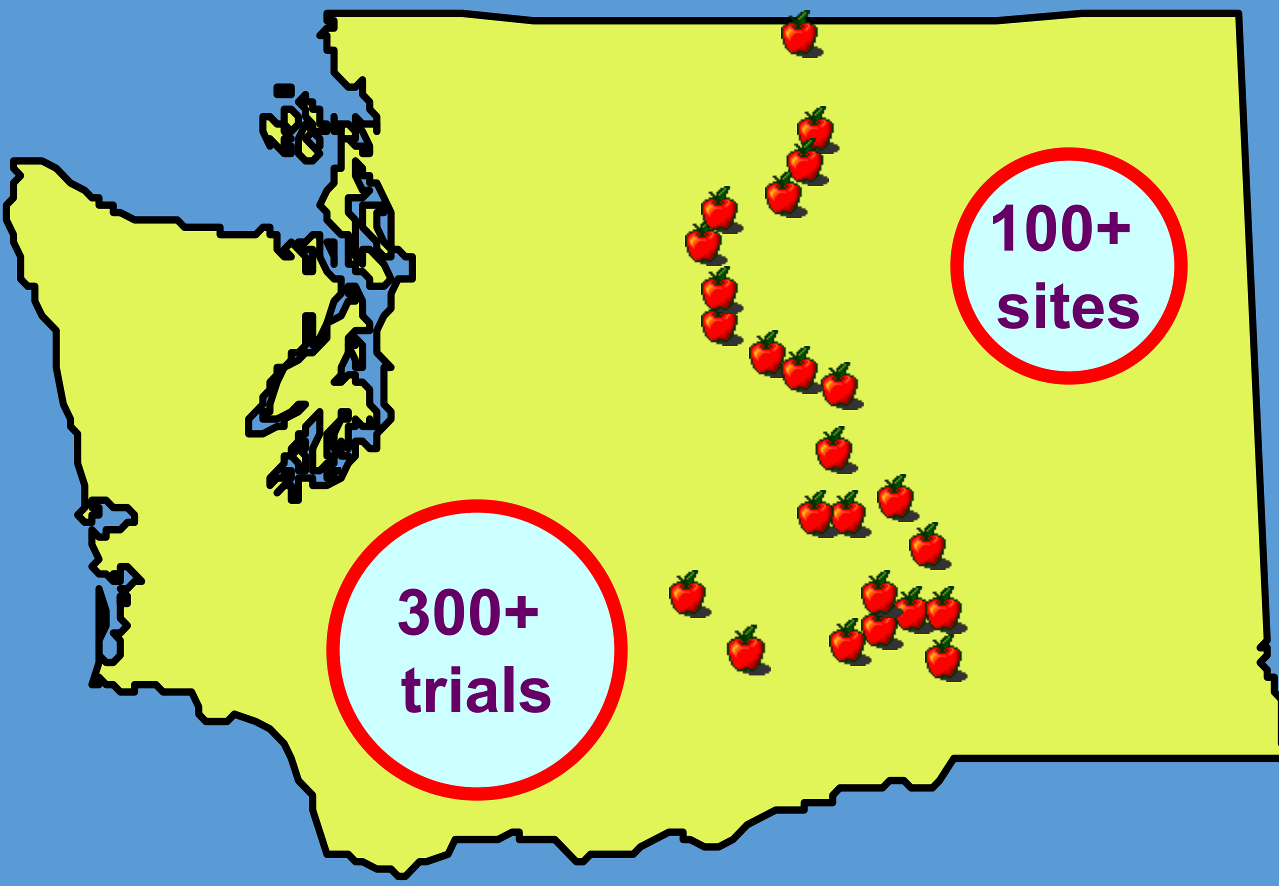
WTFRC 1998-2018

CULTIVAR

- Gala
- Fuji
- Red Delicious
- Golden Delicious
- Granny Smith
- Braeburn
- Cripps Pink
- Honeycrisp
- Cameo
- Jonagold
- Pacific Rose
- Scifresh/Jazz
- Scilate/Envy

ROOTSTOCK

- M.9
- M.26
- M.7
- MM.106
- Seedling
- Bud.9
- Nic.29
- MM.111



Slide developed by Tory Schmidt, Washington Tree Fruit Research Commission

Proven chemical bloom thinners of apple

Incidence of results significantly superior to untreated control

WTFRC apple chemical bloom thinning trials 1999-2016

Treatment	Fruitlets / 100 blossom clusters	Harvested fruit diameter	Return bloom[1]
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 / 51 (18%)
CFO + LS	62 / 115 (54%)	27 / 106 (25%)	22 / 104 (21%)
JMS + LS	14 / 24 (58%)	8 / 23 (35%)	4 / 22 (18%)
WES + LS	15 / 30 (50%)	5 / 29 (17%)	4 / 29 (14%)
ThinRite	7 / 22 (32%)	0 / 23 (0%)	0 / 12

[1] Data from 2016 trials not included

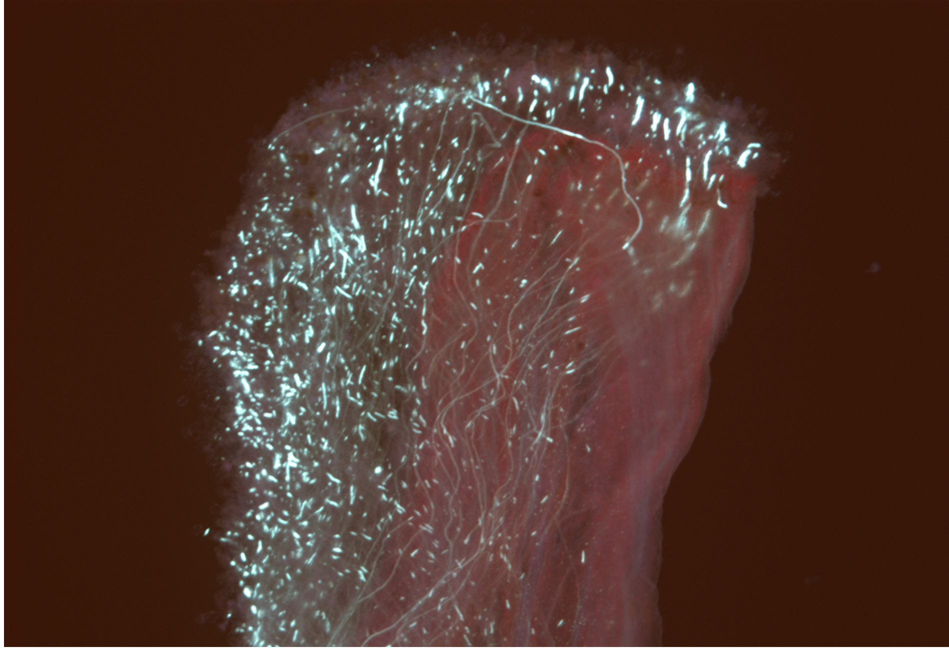
Data/Slide Credit: Tory Schmidt, Washington Tree Fruit Research Commission

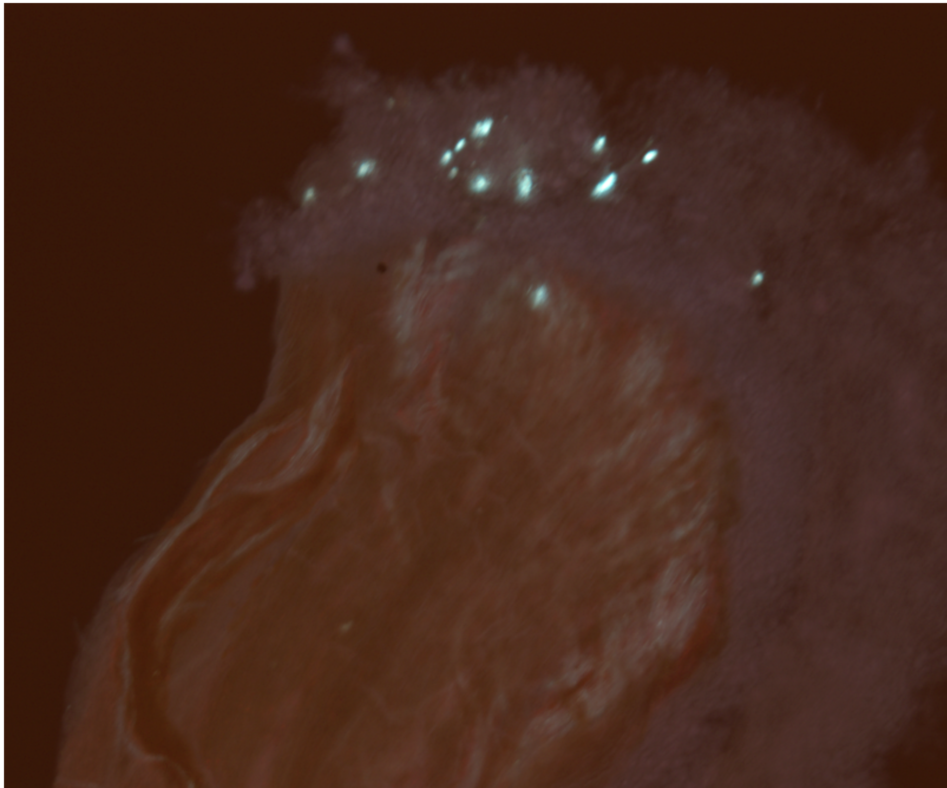
Not exactly a "new" product....

Fig. 1. Liquid lime - sulphur cooking plant, Thorsby, Alabama 1905.

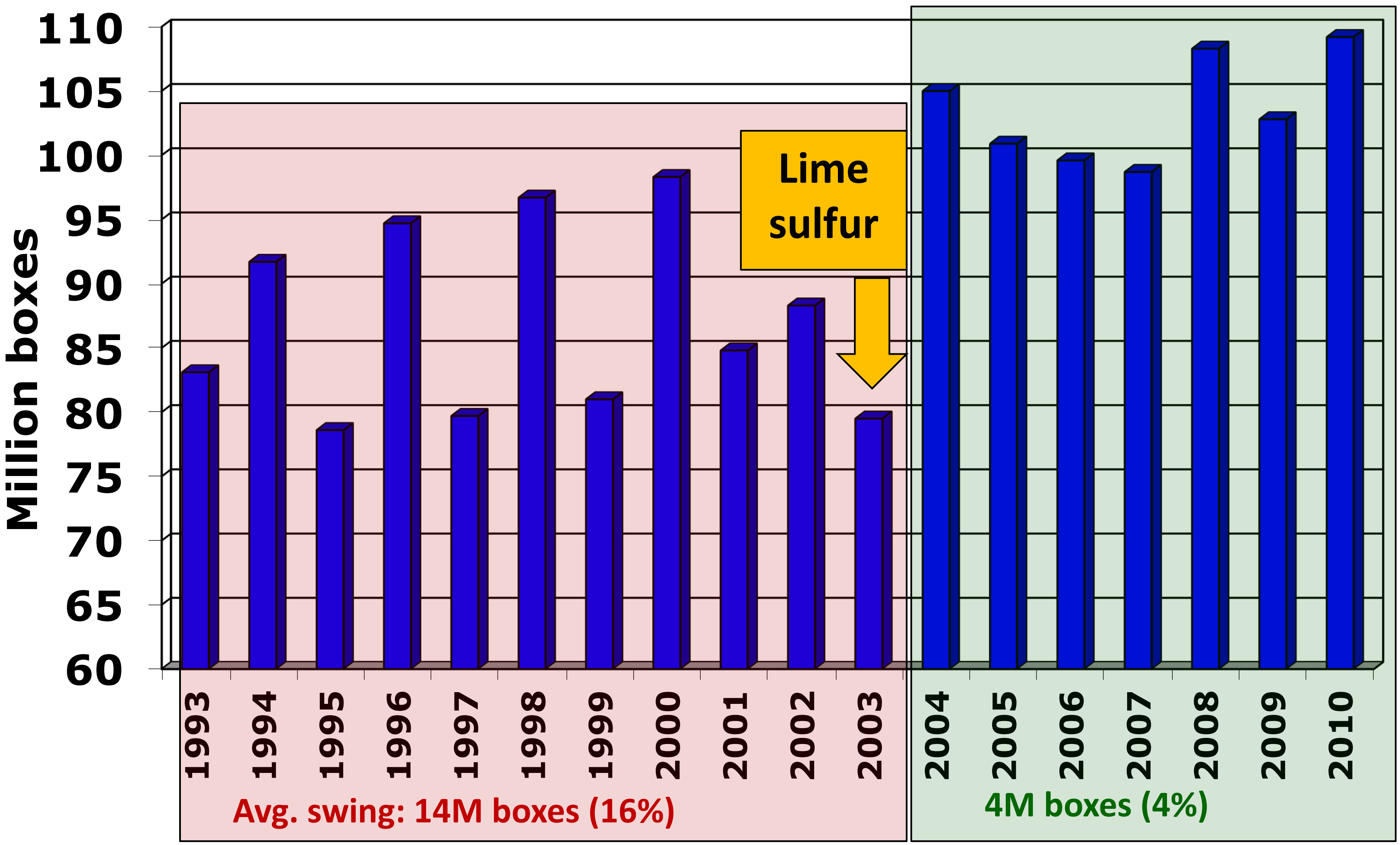
Lime Sulfur has multiple sites of action

- Inhibits pollen tube growth
  - Kick-back
- Reduces photosynthetic rate
- Combined with fish oil or petroleum-based oils
  - Increase consistency
- OMRI Certified





WA apple shipments 1993-2010



Slide Credit: Tory Schmidt, Washington Tree Fruit Research Commission

Source: WA Grower's Clearing House

Apple Crop Load Management: Is Mechanical Thinning Effective?

Could the mechanical thinner fit into an apple thinning program?

- Need for new sustainable thinning products [especially during bloom]
- Multiple mechanical thinners are available (tractor-driven and hand-held)
- May be useful with hard to thin / small fruited varieties
- Compatible with organic growing practices

- 2010 and 2011; FREC, Biglerville, PA
- Six year old ‘Buckeye Gala’/M.9
- 4 x 15 ft; Tall Spindle
- Treatments applied to the same plots in both years
- Kon et al. 2013

Treatments

1) Control
2) 180 rpm
3) 210 rpm
4) 240 rpm
5) 270 rpm
6) 300 rpm

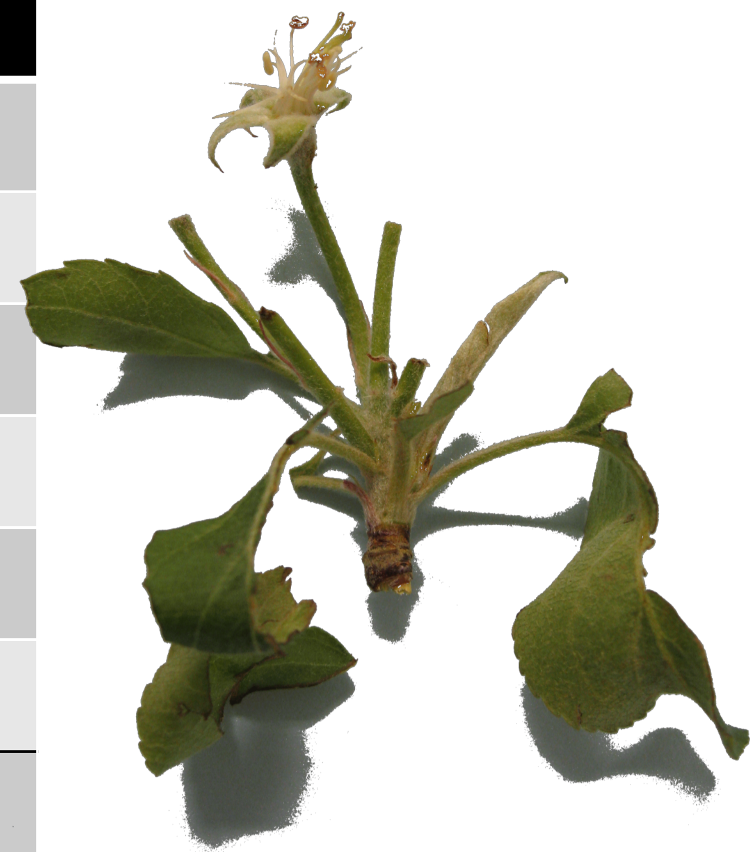
Applied at full bloom

Tractor Speed ~ 3 mph

Helical String Pattern –90 Strings

2010 Influence of thinning severity (rpm) on reproductive and vegetative tissues of 'Buckeye Gala'/M.9

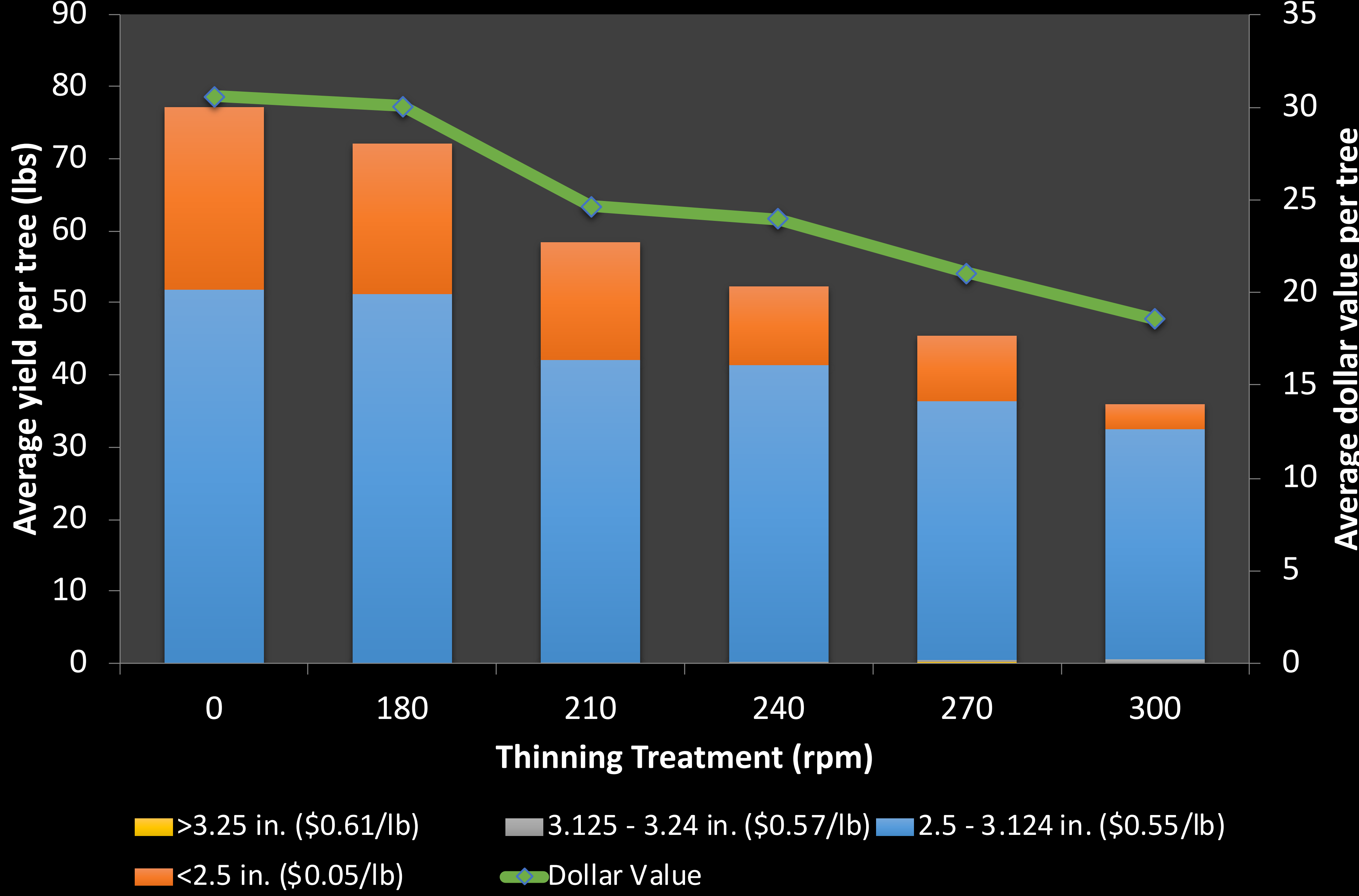
Treatment (rpm)	Blossoms / Spur	Leaf No./ Spur	Leaf area / spur (cm^2)
Control	5.3	9.7	65.2
180 rpm	4.8	8.6	59.3
210 rpm	4.4	8.2	55.2
240 rpm	3.5	7.1	36.9
270 rpm	3.3	7.4	41.4
300 rpm	2.7	7.3	36.0
Linear	<0.0001	**<0.0001**	**0.0020**
Quadratic	**0.0010**	0.0878	0.0728



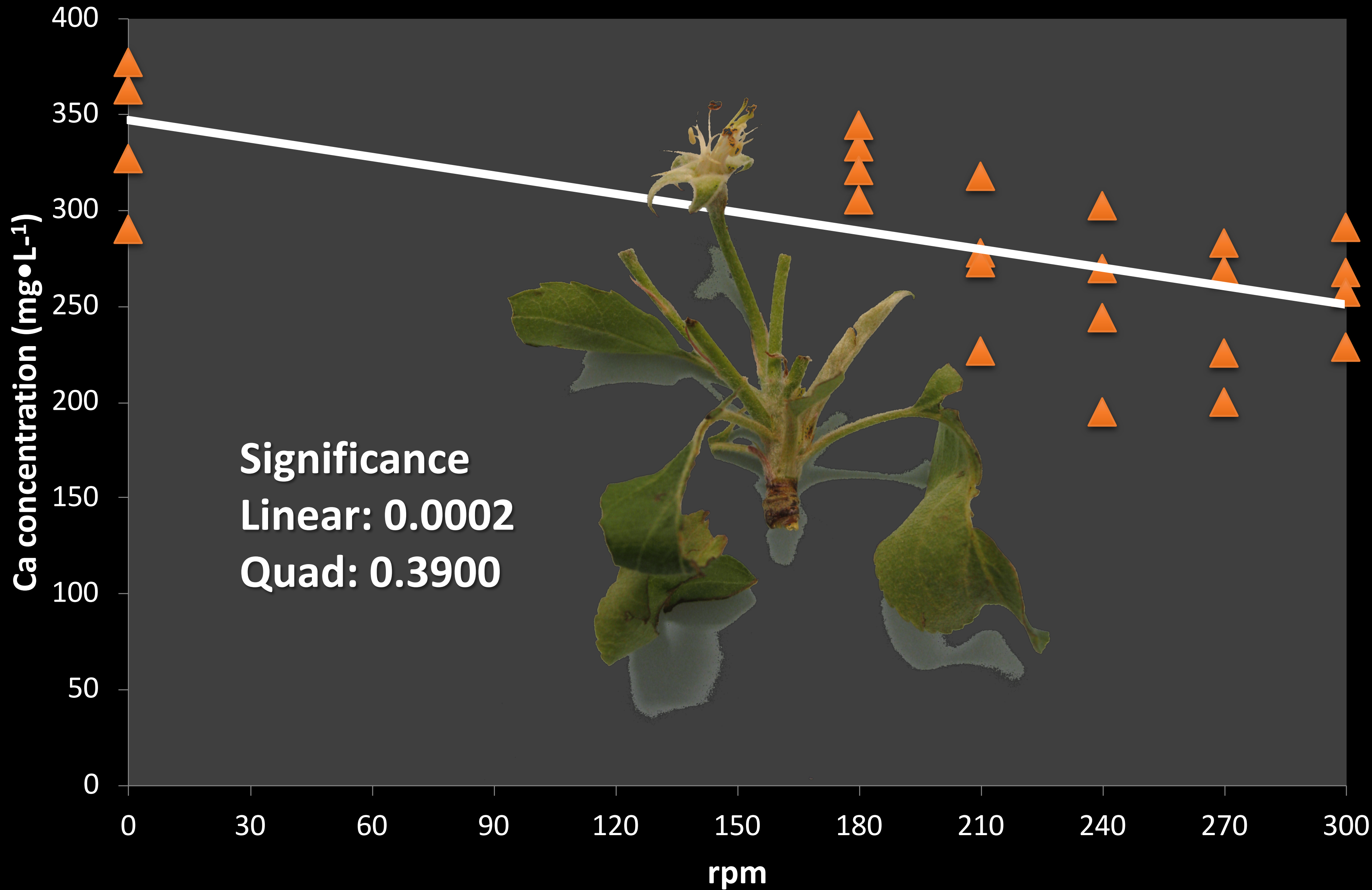
Influence of thinning severity on cropload and fruit weight of 'Buckeye Gala'/M.9

Treatment	2010 Cropload (#fruit/TCSA)	2011 Cropload (#fruit/TCSA)	2010 Fruit Weight (g)	2011 Fruit Weight (g)
Control	13.8	7.6	121	170
180 rpm	9.6	3.7	127	174
210 rpm	9.1	3.5	128	179
240 rpm	7.8	2.6	134	173
270 rpm	7.8	2.8	137	177
300 rpm	4.6	1.5	149	176
Linear	**<0.0001**	**<0.0001**	**0.0073**	0.5318
Quadratic	0.2423	0.7775	0.1251	0.8402

Influence of mechanical thinning treatments on yield, fruit size, and profitability



2010: Influence of mechanical thinning severity treatments on Ca concentration of 'Buckeye Gala' / M.9



PSU Apple Mechanical Thinning Summary

- Increased spindle speed:
  - Reduced the number / area of reproductive and **vegetative tissues**
  - Reduced crop load and yields
  - Did not have a **meaningful impact on <u>fruit size</u>, <u>return bloom</u>, and reduced <u>fruit Ca</u>**
- Control was the most profitable treatment…
- In 5 years, fruit size was only increased one time
- Compatibility of pruning / training system
- Fire blight?
- Tree damage

Outline

I. Thinning apples early: Intro

II. Early thinning strategies

   I. Pruning

   II. Chemical blossom thinners

   III. Mechanical blossom thinners

III. Summary & Future Outlook

Summary

- Significant effort to develop early apple thinners
  - Pruning severity (PSU) and spur/bud pruning
  - Over 150 chemicals evaluated
  - Multiple mechanical thinning devices
  - Great resources in the Mid-Atlantic – active research area

- New products and decision-making aids available in 2019

Outlook for 2019

- Integrating bloom thinners into eastern apple crop load management programs:
  - Will require a coordinated effort
  - Hands-on experience

- Start small!
- Another tool in the tool-box → Not one size fits all

Acknowledgements

- Graduate program at PSU: Edwin Winzeler, Melanie Schupp, FREC Staff and Students, PSU Extension
- State Horticultural Association of Pennsylvania; YGA
- Special Thanks to Tory Schmidt; Washington Tree Fruit Research Commission

References

- Kon, T.M. and J.R. Schupp. 2018. Apple crop load management with special focus on early thinning strategies: a USA perspective. Hort. Rev. 46:255-298.
- Kon, T.M., J.R. Schupp, K.S. Yoder, L.D. Combs, M.A. Schupp. 2018. Comparison of chemical blossom thinners using ‘Golden Delicious’ and ‘Gala’ pollen tube growth models as timing aids. HortScience 53:1143-1151.
- Schupp, J.R., H.E. Winzeler, T.M. Kon, R.P. Marini, T.A. Baugher, L.F. Kime, and M.A. Schupp. 2017. A method for quantifying whole-tree pruning severity in mature tall spindle apple plantings. HortScience 52:1233-1240.
- Schupp, J.R. and T.M. Kon. 2014. Mechanical blossom thinning of ‘GoldRush’ / M.9 apple trees with two string types and two timings. J. Amer. Pomol. Soc. 68:24-32.
- Kon, T.M., J.R. Schupp, H.E. Winzeler, and R.P. Marini. 2013. Influence of mechanical string thinning treatments on vegetative and reproductive tissues, fruit set, yield and fruit quality of apple. HortScience 48:40-46.

Thanks for your attention!

tom_kon@ncsu.edu