The potential use of insect exclusion/anti-hail nets to reduce or eliminate apple thinning

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## **Challenges in organic fruit production**





Hand thin in organic apple orchards represents up to 20% of total labor budget



## **Use of nets in apple production**

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- WA certified organic apple orchards = 28,473 acres (2018)
- ≈12% WA apple orchards under netting (forecast by end of 2018); 89% are Honeycrisp and Granny Smith (Mupambi et al., 2019)
- To reduce damaging effect by <u>environmental stress</u>: hail, wind and high light intensities (i.e. sunburn) Racsko and Schrader, 2012, Kalcsits et al., 2017)
- To reduce adverse effect by <u>biotic stress</u>: insects/birds (singlerow/drape net for insects exclusion, *Mupambi et al., 2019*)



# Objectives

- Determine if enclosing apple trees in netting at specific percentages of open bloom could reduce pollination, fruit set, and thinning
- A secondary objective was to evaluate the effect of nets on productivity, fruit size, and quality
- <u>Hypothesis</u>: Netting will produce a range of crop loads depending on the percentage of open bloom accessible to pollinators prior to the time of canopy enclosure.

## Netting Trial: Gala, The Ridge, MI

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## Netting Trial: Gala, The Ridge, MI

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 Despite netting trees as early as Pink (0% open flowers), netting had no (2017) or little (2018) effect on 'Gala' fruit set

## 2017 MI Netting Trial: Gala

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2017 Treatments	Avg. Tre	ee Yield	Fruit weight	Red overcolor	Firmness	SSC	Shape
	(Kg)	(no.)	(g)	(%)	(Kg)	(%)	(l:w)
Non-netted	23.0	181.1	127.2	39	3.83 a <sup>y</sup>	12.1	1.10
Netted 0% (Pink)	20.6	160.3	128.2	41	3.68 ab	12.0	1.09
Netted 26% (KB)	21.5	164.5	130.5	36	3.57 bc	11.9	1.09
Netted 60% (KB)	21.5	159.0	135.5	33	3.51 c	11.8	1.08
Netted 95% (KB)	20.9	162.6	128.4	35	3.76 a	11.8	1.10

### Netting Trial: 2017 Seed content



 In 2017, netting reduced seed number (4 per fruit for control and ~1 per fruit for net treatments) and increased % of seedless fruit

### Netting Trial: Gala, Sparta, MI

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- In 2018, netting had no effect on yield
- Fruit size, however was reduced by 15%

## Netting Trial: 2018 Seed content

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- In 2018, a similar trend was observed
- However, seed content was higher (no frost events) and no seedless fruit were observed

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#### Results: Fruit set (2017-2018)





[num fruit harvested/tree]

% fruit set =  $\frac{1}{[total num flower clusters x 5 HC flowers/clusters]}$ 

#### **Results: Yield (2017-2018)**

trt 2017	Avg no. apples/ tree at harvest <sup>¥</sup>		Avg. Yield/tree (kg/tree)		Avg. Fruit weight (g)	
non-netted 2018 (no thin, thinned 2017)						
non-netted 2017 (no thin) 🗲	366	а	35.1	а	96	с
non-netted 2017 🛛 🔶	139	b	27.8	ab	204	а
Netted 0% (Pink)	148	b	22.3	b	155	b
Netted 23% (KB)	213	b	31.7	ab	151	b
Netted 58% (KB)	217	b	31.6	ab	146	b
Significance	***	k	*		***	k

Significance of the model: \*=p<0.05, \*\*= p<0.001, \*\*\*=p<0.001. Mean separation among treatments by Tukey HSD (P < 0.05), whereby means associated with different letters are significantly *different.* harvest<sup>¥</sup> 09 September 2017

harvest<sup>∫</sup> 23 August 2018

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#### Results: Seed analysis (2017-2018)



Elsysy, Serra, Schwallier, Musacchi, Einhorn, 2019 Agronomy (submitted)



#### Results: In-field packout 2017-2018

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Honeycrisp 2017 harvest packout: % of good versus cull apples by treatments (*N*= tree reps, total 4341 apples, bars =±SE) ■ % good (\*\*\*) 100% 90% 80% 70% 60% 50% 32.6 40% 1.2 a '0.2 a 30% 20% 7.8 b 10% 0% 0% KB [N=4] 23% KB 58% KB Non-netted Non-netted [N=4] [N=4] (no thinned) (Hand thinned) [N=4] [N=4] treatments 2017

## Netting Trial: 2017/18 WA Honeycrisp MICHIGAN STATE Extension

Table 3. Effect of netting treatments in 2017 and 2018 on average tree yield and number of fruit, average fruit weight, and fruit quality attributes; red color (percentage red), flesh firmness, soluble solids concentration (SSC), nondestructively predicted dry matter (%), and shape of 'Honeycrisp' fruit 1 month after harvest (RA storage).

Treatments	Avg. ( (kg)	Tree Yield (Fruit no.)	YE (kg·cm <sup>-2</sup> )	Cropload (Fruit no./cm <sup>2</sup> )	Fruit Weight (g)	Red Color (%)	Firmness (kg)	Dry Matter (%)	SSC (%)	Shape <sup>z</sup> % Misshapen
					'Honeycris	2017				
Non-netted (Nonthinned)	35.1 a y	366 a	1.4 a	14.5 a	96 c	53 a	6.5	14.5 d	11.1 ь	47.6
Non-netted (Hand thinned)	27.8 ab	139 b	1 b	5 c	204 a	46 a	6.6	15.2 bc	11.4 ab	33.8
Netted 0% (Pink <sup>w</sup> )	22.3 b	148 b	0.9 b	6.3 bc	155 b	44 ab	6.7	15.8 a	12 a	45.1
Netted 23% (KB)	31.7 ab	213 b	1.1 b	7.1 bc	151 b	32 b	6.5	15.6 ab	11.5 ab	47.7
Netted 58% (KB)	31.6 ab	217 b	1.2 ab	8.4 b	146 b	3 <b>1</b> b	6.3	14.8 cd	11 b	48.4
					'Honeycris	′ 2018				
Non-netted (Thinned 2017)	31.7 a	338 a	1 a	11.1 a	94 c	55 ab	7.1 c	15.1 b	12.1 d	45.1
Non-netted (Nonthinned)	5.1 c	35 b	0.18 c	1.2 b	152 b	68 a	8.3 a	17.6 a	14.7 a	32.9
Non-netted (Hand thinned)	16.9 b	74 b	0.58 b	2.5 b	234 a	52 bc	7.6 b	17.3 a	14.2 a	48
Netted 0% (Pink)	12.1 bc	50 b	0.47 bc	2 b	240 a	40 c	7.6 b	17.3 a	13.6 b	54.5
Netted 28% (KB)	14.9 bc	59 b	0.46 bc	1.8 b	257 a	45 bc	7.5 bc	17.1 a	13 c	56.4
Netted 68% (KB)	16.9 b	71 b	0.58 b	2.4 b	242 a	49 bc	7.6 b	17.2 a	13.3 bc	51.6

<sup>2</sup> Shape was expressed as percentage of fruit asymmetrical in both horizontal and vertical plane. <sup>9</sup> Mean separation among treatments by Tukey HSD (p < 0.05), whereby means associated with different letters are significantly different. <sup>w</sup> Pink, pink stage of bud development; KB, king flower bloom. <sup>9</sup> Data are means of four replicates. Mean separation among treatments by Tukey HSD (p < 0.05), whereby means associated with different letters are significantly different. n = 4 for yield, YE, crop load, and avg. fruit wt; n = 24 and 40 for individual fruit quality attributes for 2017 and 2018, respectively.



- Honeycrisp (WA) set an equivalent crop to hand-thinned controls at early net enclosure timings in both years
- Fruit quality was not
  negatively impacted by nets
  (shape, size, dry matter,
  SSC)

### Conclusions

 Natural fruit set ranged from 16 to 23% (at harvest) but commercially is adjusted to 7-8% by hand thinning.

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- In both years the no-netted un-thinned controls proved to possess strong natural tendencies toward biennial bearing.
- Between 23% to 68% open king flowers are needed to reach yields similar to commercial standard trees (thinned no net) for organic HC.
- Use of nets as a barrier for bees worked, but still year-by-year fluctuations in crop load were observed.
- The deployment of nets from 0% KB to up 68% KB open impacted fruit size: reduction in 2017 under nets, but not in 2018. Sunburn was absent under nets (up to 4.7% in no-netted no thinned 2017-2018).

## How to optimize thinning strategy by netting?

- Better prepare canopies for drape netting; thinner canopies facilitate light penetration
- Consider green pruning to reduce vigor (depending on the cultivar).
- Optimize training system to 2 or 3-axis trees to achieve a more planar canopy.
- Select the most suitable cv/rootstock combination for organic apple farming (vigor, nutrition, etc..)
- Optimize timing of nets closure for sufficient pollination without compromising fruit quality.
- Consider the combination of netting with reflective fabrics to improve fruit color.

## 2019 Netting Trial: Honeycrisp

283 a

1.07

**Net 75%** 

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5.9 ab



3.4 b

0.04 b

## 2019 Netting Trial: Sweet Tango

164 b

1.05

**Net 75%** 



**4.4** ab

0.07 b

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4.8 ab

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## 2019 Netting Trial: Fuji

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Treatment	Fruit wt.	Misshapen		Seeds	
Fuji	(g)	L:W	Mature	Non-mature	Non-fertilized
No net	199 b	1.15	<b>7.9</b> a	0.11	1.05 b
Net Pink	214 ab	1.11	5.6 b	0.18	<b>2.07</b> a
Net 20%	<b>218</b> a	1.26	5.1 b	0.12	<b>2.53</b> a
Net 45%	<b>226</b> a	1.12	<b>8.2</b> a	0.07	0.61 b
Net 70%	<b>222</b> a	1.07	<b>7.9</b> a	0.09	0.67 b

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# <u>Summary</u>

- Net enclosure did not reduce fruit set or yield of Gala but did affect seed content
- Gala set a full crop of low seed content fruit under frost conditions (~70% seedless) and under normal conditions, via self pollination or (possibly) via native pollinators and/or wind disseminated pollen
- Honeycrisp (WA) set a crop roughly equivalent to hand thinned controls with minimal effects on fruit size or quality when nets enclosed trees between 20-60% bloom
- Different cultivars responded markedly differently to netting

# Thank you for your attention

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