

# Western Cascade Fruit Society Grant Project Final Report

Grant Received April 2018  
by City Fruit  
Barb Burrill, Orchard Manager

## **TITLE of FRUIT RESEARCH PROJECT**

Compare effectiveness of two mesh sizes when using exclusion netting to reduce codling moth and apple maggot damage in urban apple trees.

## **DURATION**

May 7, 2018 – October 20, 2018

## **OBJECTIVES**

Our objectives for this research project were to learn answers to these questions:

- 1) Does the smaller mesh netting better protect apple trees so that they produce more apples free of codling moth and apple maggot damage?
- 2) Is the smaller mesh netting as sturdy and resistant to tearing and raveling as bee netting?
- 3) Are there other advantages or disadvantages to using the smaller mesh netting?



## **MATERIALS**

Regular mesh netting, 2 rolls: \$446.07  
Small mesh netting, 2 rolls: \$448.11  
Zip ties: \$66.55  
Clipboard: \$2.19  
Total supplies: \$962.92

Technical help/management:  
More than proposed 34 hours

Grant monies unused: \$0

## **METHOD – with REVISIONS**

### **Tree Selection**

Choose ten apple trees at Meridian Playground that can be divided into three sections, so that a third of the tree's branches are netted with a large mesh net, the other third with a small mesh net, and the last section will be left unnetted as a control.

Revised: We worked with 14 trees representing nine cultivars. Cultivars with only one representative tree in the orchard received the standard installation of one small mesh net, one large mesh net, and a third area uncovered:

Red Delicious

Duchess of Oldenburg

Ontario

Northern Spy

Honeygold (tentative ID is a Golden seedling, for clarity we use the former name)

Reinette Rouge D'Etoilee (identified 2018, previously called Lady or crabapple)

Golden Delicious

Cultivars where more than one tree exists:

Winter Banana: Seven trees exist at Meridian Playground and we netted all or part of three trees. We installed one net on each tree. We covered one tree completely in small mesh net, one completely in large mesh net, and then covered one large branch on a third tree with small netting. We collected unnetted apples from all Winter Banana trees.

Northwest Greening: Two trees. We netted one in the standard three sections and installed a small mesh net on half of an adjacent tree and left the other half of that tree uncovered.

Rhode Island Greening: Two trees. We netted one in the standard three parts. An adjacent tree was too fragile to net so we used it only for collecting unnetted apples. We had a smaller than ideal sample size overall from this cultivar.

### **Netting Structure Installation**

We installed netting structures on all trees except for the Winter Banana trees. The Winter Banana trees are very large, typically have the most pest damage, plus are the least desirable for food bank donations. Rather than leave them out of the study completely,



we focused our energy for installing netting structures on the other cultivars.

We learned that preparing to net a tree in three sections – including pruning the branches so that two nets can be independently installed and cinched around a trunk or large branch – is extremely time consuming.

This specialized pruning required at least two pruner hours per tree. Installing the bamboo poles took another 2-3 people at least 2 hours per tree. Throwing a net over just part of the tree and weaving it between branches, even after pruning, took much more time than throwing a larger net over the entire tree. Time for zip tying and cinching the net did not take twice as long, given as each net was covering a smaller area.

### **Monitor Tree Nets, Count and Examine Fallen Fruit**

The need for counting fallen fruit on the ground and in nets started slow and increased dramatically over time, as all but one variety were fall-ripening apples. At first, we didn't need to visit every tree each week to count apples, but as a result we also didn't examine every net for holes or gaps. Vandalism of the nets was not as much of a problem this year as in past years, as far as having holes cut in the nets, but the fact that we had twice as many nets per tree introduced the likelihood of net gaps due to gravity and visitors. Meridian Playground is a busy public park, and the netted trees are a curiosity for many.



### **Recording data**

Counting, examining, and logging the fallen apples became a skill quickly learned by several hardy volunteers. A core group of five people regularly collected and examined the apples. We modified the paper forms over time to account for the types of insect and disease damage we encountered, which varied from one cultivar to another. The idea of online data entry was discarded early on as the paper form layout was always changing.

The paper form categories began with combinations of insect and disease damage. Ultimately, we logged each type of damage individually while also including an overall count of apples. Logging every possible combination of damage that we saw on apples (such as CM + scab + leafroller 1 and 2, etc.,) became unwieldy as each cultivar presented its own damage profiles. Starting in October we simply counted each apple and then used a tick mark in a column to log each type of damage present on that piece of fruit.

Because of the variation as to how data was collected over six months, significant time was spent unbundling and recategorizing data so that insect and disease damage were

consistently represented in the same way for all fruit collected. But now we have forms that can be used by anyone else doing similar research.

Beginning form:

				In net	In net	In net	In net	In net	In net	
Date	Tree Label	Net Type	Net status	No Damage	CM	AM	CM & AM	Other Pest	Disease	Notes
Sep 8	AP08	Small	Hole 3x6"	2	0	0	0	0	0	Repaired hole
Sep 8	AP08	Large	OK	3	1	0	2	0	0	
Sep 8	AP08	No net								

Ending form:

DATE:

Tree Label	Net Type	Total #	No Damage	CM	LR 1 <sup>st</sup> Gen	LR 2 <sup>nd</sup> Gen	AM	Scab	BMSB	Net Status Notes
AP08	Small									
AP08	Large									
AP08	No net									

### Volunteer Labor Made It Happen

One paid City Fruit staffer managed this study. All other labor was provided by 85 volunteers who contributed 336 hours to complete this study.

Volunteers installed the bamboo poles and tennis ball structures to keep the nets off branches and fruit. They netted all or part of 14 apple trees with 22 individual nets. The first tree was netted May 25 and the last June 27.

Volunteers monitored the nets at least weekly beginning July 10 and ending with the last harvest October 20.

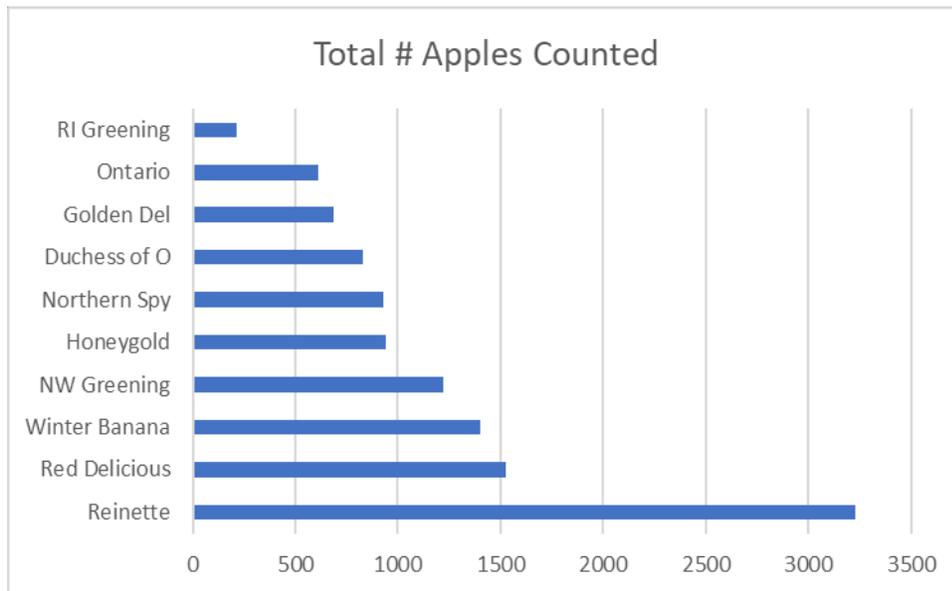
Volunteers harvested the apples from the trees included in the study. 900 pounds of pest-free apples were donated to local food banks and the Good Shepherd Center annual apple tasting event. (The Good Shepherd Center orchard is on the same larger property as Meridian Playground orchard and is managed by its full-time gardener, a Historic Seattle employee.)

3100 pounds of pest damaged apples were supplied to local commercial cider makers.

1100 pounds of inedible apples were collected by Seattle Public Utilities for the city's commercial compost program.



11,652 apples were collected, examined, categorized, logged, and counted by volunteers.



## **FINDINGS RELATED to STATED OBJECTIVES**

Our objectives for this research project were to learn answers to these three questions:

- 1) Does the smaller mesh netting better protect apple trees so that they produce more apples free of codling moth and apple maggot damage?
- 2) Is the smaller mesh netting as sturdy and resistant to tearing and raveling as bee netting?
- 3) Are there other advantages or disadvantages to using the smaller mesh netting?

We will answer questions 2 and 3 first.

Both types of what is commonly called hail or bee netting have the same sturdy type of weave or knotting so the smaller mesh net is no more likely to ravel. Both sizes of netting do not ravel or rip when cut.

The small mesh netting is made of thinner strands of HDPE, though, which makes it lighter in weight and softer in texture, easier to handle for a long time without gloves. We found that the smaller mesh netting was more likely to tear when pulled against a snag or stubbed tree branch, as its thinner strands are just not as sturdy as the heavier large mesh strands.



New tree growth can push through either size of mesh. This is most noticeable on the top of the tree. Using a structure such as bamboo poles to keep the net away from branches and vigorous top growth helps reduce the number of branches that grow through the net.

One feature of the smaller mesh netting that we used was both an advantage and a disadvantage. When we ordered the custom run of the small mesh netting from the factory, we were able to have it made in any width we desired. The larger mesh netting that we have used in the past comes only in 17' width, on a roll. The 17' width is fine for smaller trees, but most of the orchard trees we care for are 15+ feet tall, some much taller. For the

larger trees we sew two widths of netting together to create a 34' wide net, which is a good size for trees 15-20' tall.

We ordered the small mesh netting in a 36' width. That made sense if the tree was large and we were covering the entire tree with one net. But since we were installing two nets per tree, each covering only 1/3 of the tree's canopy, we rarely needed a net that large. We often found that we had a lot of additional netting bulk that wasn't necessary. It was good that the smaller mesh was lighter weight as we had to tie up a lot of extra netting volume to keep it off the ground.

The small mesh netting also came with three wide colored stripes that ran the length of the net. The color was useful as a contrast to the plain white large mesh netting. The stripes also helped workers orient the netting during installation.

Another disadvantage of having the netting 36' wide is that the resulting roll of netting was so much heavier than the 17'x300' netting we had worked with before. The extra weight and bulk of the 36'x180' roll was difficult for most women – and some men – to haul without help from another person or a hand truck.

Back to question # 1.

### **Does the smaller mesh netting better protect apple trees so that they produce more apples free of codling moth and apple maggot damage?**

It took about a month to install the nets on the trees in our study, which introduced another variable, time delay. In large part because of the significant extra time required to prune the tree so it could be separated into netted portions, and then to zip tie bamboo poles to branches, we completed installation of nets much later than our goal of the end of May, which is when the first generation of codling moths typically emerge from the ground.

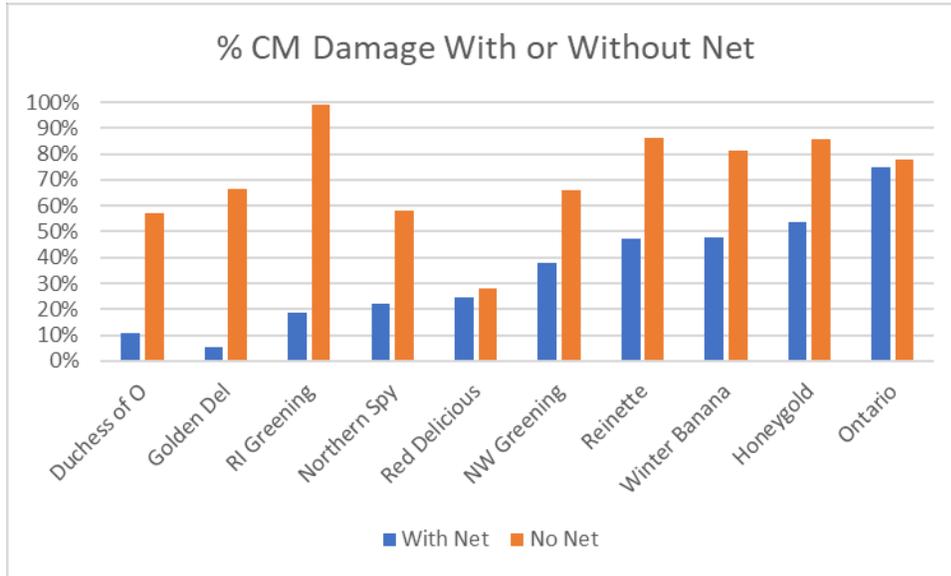
When we first started installing netting, we learned that the codling moths were emerging this year even earlier than normal. And when we were halfway through installing netting, we saw actual damage on fruit from the first generation of moths. We were too late in getting the nets on.

We collected data on each apple collected from each tree, and from the ground underneath each tree and neighboring trees if of the same cultivar. We categorized each apple based on the evident pest or disease damage and totaled this numbers according to tree, whether that part of the tree had been covered with a small mesh net, a large mesh net, or no net. We collected apples from within the net if they fell and harvested fruit off the tree when the fruit was ripe.

But despite early-flying moths and late net installations, we saw real evidence of effectiveness of the nets. Had we installed all nets before the overwintering codling moths

emerged, our results would undoubtedly have included even more pest-free fruit. But still, the positive effect of netting *at all* is very clear.

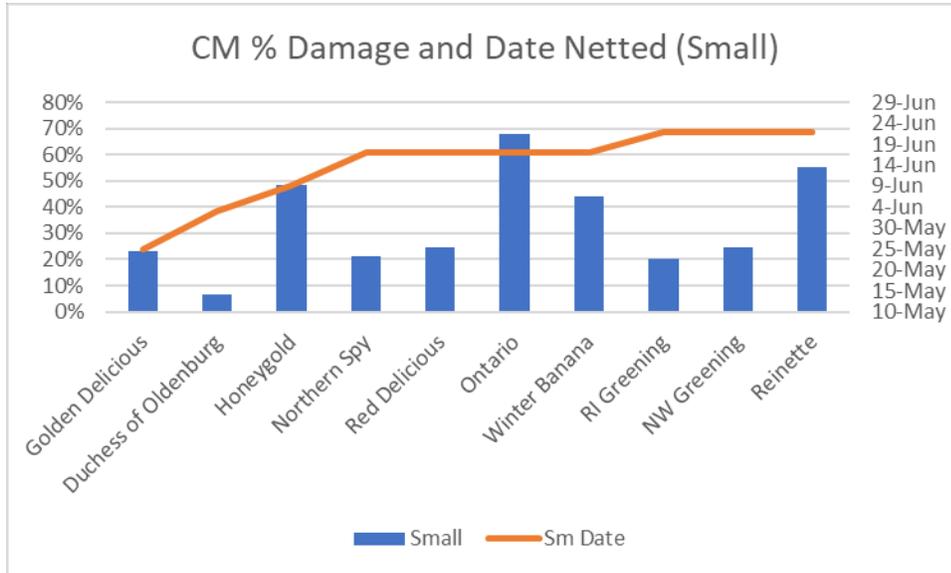
Yes, netting apple trees, even a month after codling moths are flying, helps prevent further damage. This chart shows the results for all cultivars in our study, for all apples examined:



Cultivar	With Net	No Net	Reduced Damage with Net
Duchess of Oldenburg	11%	57%	46%
<i>Golden Delicious</i>	6%	67%*	61%*
<i>RI Greening</i>	19%	99%*	81%*
Northern Spy	22%	58%	36%
Red Delicious	25%	28%	3%
NW Greening	38%	66%	28%
Reinette	47%	86%	39%
Winter Banana	48%	81%	34%
Honeygold	54%	86%	32%
Ontario	75%	78%	3%

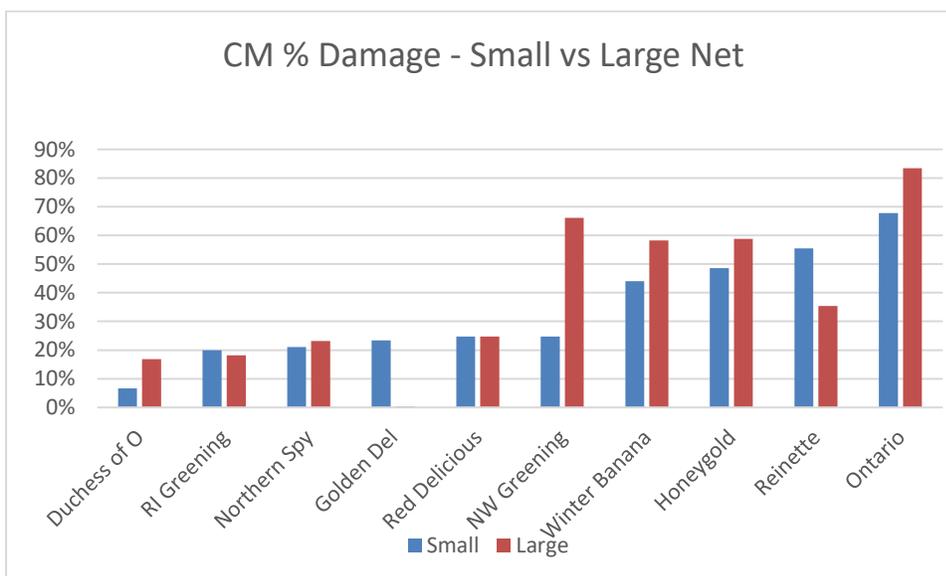
“No Net” results for two of the cultivars (in italics) should be discounted due to the small sample of apples on the ground. Almost no apples fell to the ground or remained to be harvested of the unnetted section of the Golden Delicious tree. (We are not sure what happened to those apples. Another risk of working in a public space.) The Rhode Island Greenings had some fallen apples but very few.

Effectiveness of the netting is not totally related to when the netting was installed, but apparently more so to how attractive the cultivar is to the insect pests. This chart shows the percentage of codling moth damage within a small net per cultivar with the blue bar compared to the orange line which tracks the date when the small net was installed.



Was one type of netting superior to the other in preventing codling moth damage? The data does not support one or the other. In most cases the overall attractiveness of the cultivar to codling moths counted more than effectiveness of either size of mesh. Where there was a pronounced variance between the two can be attributed to another issue such as gaps in the net on the NW Greening and Golden Delicious.

The following charts compare % damage between trees protected by large or small nets.



### Difference between CM % Damage Between Large and Small Nets

	Small	Large	Large - Small
Duchess of Oldenburg	7%	17%	10%
RI Greening	20%	18%	-2%
Northern Spy	21%	23%	2%
Golden Delicious	23%	0%	-23%
Red Delicious	25%	25%	0%
NW Greening	25%	66%	41%
Winter Banana	44%	58%	14%
Honeygold	49%	59%	10%
Reinette	55%	35%	-20%
Ontario	68%	83%	16%

### Apple Maggot Damage

Apple maggot damage was almost non-existent at Meridian Playground. It occurred in cultivars that were historically most attractive to insect pests, such as the Ontario.

Exclusion netting is particularly effective in keeping out apple maggot damage, as a few years ago unnetted Ontario apples were nearly 100% damaged by apple maggot. Overall AM damage in the apples in the study was less than 1%.

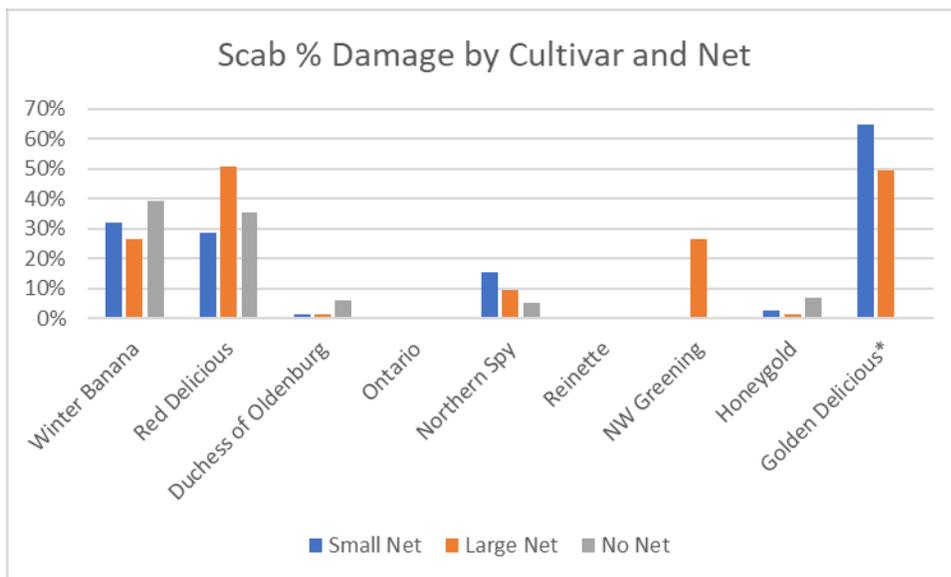
### Apple Maggot Fly Damage, With or Without Net

	Small	Large	No Net
Winter Banana	0%	0%	0%
Red Delicious	0%	0%	0%
Duchess of Oldenburg	0%	0%	1%
Ontario	5%	2%	27%
Northern Spy	0%	2%	2%
Reinette	0%	0%	0%
NW Greening	1%	0%	0%
Honeygold	0%	0%	0%
Golden Delicious	2%	2%	0%

## Netting related to occurrence of scab

Some fruit tree experts have warned against using netting as they expect that scab would occur more frequently on apples that are netted compared to unnetted fruit. Our data does not support this. The data suggests, again, that a cultivar that suffers from scab is prone to that disease whether the fruit is netted or not.

Two cultivars at Meridian Playground are very susceptible to scab: Red Delicious and Golden Delicious. Our data shows that with the Red and Golden, scab is the primary form of damage to the fruit. In the chart below, the higher incidence of scab on the Red Delicious with the small mesh net may be due to that section of the tree with the being in the shadiest side of the tree.



## Other Insect Pest Damage: Leafroller

Soon after we started examining fruit, we noticed extensive fruit damage due to leafrollers, most likely the two generation pandemis leafroller. We first saw first generation or overwintering leafroller damage such as shown in the photo at right.



We learned in late September that holes in fruit that didn't involve damage to the core (codling moth) were probably second or summer generation leafroller damage. Encountering new types of pest damage was a challenge for our volunteers but now we have a team of pest damage identification experts!

Leafroller larvae overwinter in crevices in the bark of an apple tree, then emerge when fruit buds open. The first-generation larvae chew on tiny fruit, causing the tan scabby russeting and extreme deformity in apples as they increase in size. The damage does not go below the skin surface.



2nd Generation Leafroller Damage - mid season

Eggs of the second-generation hatch from late August to mid-September and possibly into October. These larvae feed on ripe fruit and create shallow holes and chewed areas. The larvae feed for a short time before moving to bark and scaffold limbs in October to overwinter.

Why is this particularly disturbing when we are studying pest control netting? The leafroller larvae overwinter in the bark of the tree and emerge early enough to chew on buds before fruit develops – so netting in May or even earlier in the spring will *not* keep the first generation leafroller larvae from emerging and chewing on the immature fruit. All this work with netting and we discover a new pest with a totally different life cycle!

Another leafroller question: How do the summer generation larvae get inside the net? Adult leafroller moths are larger than codling moths and apple maggot flies, so couldn't get through the net mesh. Do they lay their eggs through the net or do they mate inside the net? We did not see any moth bodies.



2nd Generation Leafroller Damage - late season

Whether or not we know how the second-generation larvae got to the mature, ripe fruit to chew holes, they did. Our apples suffered two types of damage from two generations of leafrollers. In some of the cultivar we studied, leafroller damage was more common and more deforming than codling moth damage. Netting is not the answer to avoiding this pest. We will be investigating steps to take next year to avoid damage from leafrollers.

## **Other Insect Pest Damage: Brown Marmorated Stink Bug**

We saw slight evidence of Brown Marmorated Stink Bug (BMSB) damage. We are less concerned about BMSB damage as exclusion netting should serve as a barrier against BMSB laying eggs on fruit trees.

### **SUMMARY**

We did not see a measurable difference in effectiveness between using a small mesh or regular mesh net. Use of either type of net as an exclusion net – completely enclosing the tree – is an effective, organic, no-kill way to reduce codling moth and apple maggot damage. Ideally, the netting is installed before the overwintering codling moths emerge, but if not, it still provides significant protection from damage from later generations.

The widest variance of CM and AM damage arose from the relative attractiveness of cultivars to insect pests. In one case, the Ontario apple, is the most popular with codling moths and apple maggots as it is with humans. (In October 2018 the Ontario was voted the most popular apple at the Good Shepherd Center apple tasting, winning over 22 other mostly heirloom varieties all grown on site.) One thing the data does show us is which cultivars should be netted first!

Using netting structures does seem to improve the effectiveness of the netting. We didn't see the pattern of CM "stings" from having the netting pulled tight around the spread of a netted tree. An ideal type of structure for different sizes of fruit trees warrants further research.

The smaller mesh netting is less durable than the larger mesh netting, based on its thinner HDPE fiber. It is lighter weight, though and softer when working with ungloved hands.

We could not determine whether netting of either size is a factor for increased damage from second-generation leafroller. Further understanding of the leafroller's life cycle is required.



**Meridian apples ready for the GSC tasting event**

## **Next Steps**

We will be asking for a second year of funding to continue with another netting study, this one among residential fruit tree owners in Seattle. We will either invite City Fruit members to enroll their apple and pear trees or create a focused project in one Seattle neighborhood. Codling moth in Asian pears has become a big problem with Seattle trees, so we would include pear trees in our netting study.

We now have detailed experience with the process, data collection forms, lots of photos of pest damage for training and reference, and access to bamboo poles, tennis balls, and bicycle inner tubes to prepare homeowner trees for netting.

We could offer home tree owners nets at a discount, provide training, and support them throughout the netting project life span, including collecting data from their netting and harvest activities.

