

**Project Title:** Phase 3 Evaluations of Apple Breeding Program Selections

**Report Type:** Final Project Report

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**Project Duration:** 3 Year

**Total Project Request for Year 1 Funding:** \$ 50,813

**Total Project Request for Year 2 Funding:** \$ 51,702

**Total Project Request for Year 3 Funding:** \$ 52,559

**Other related/associated funding sources:**

**in kind contributions: \$30,000.**

**Notes:** Stemilt and Allan Brothers provide farm crew assistance for pruning, thinning, and field maintenance, Agrofresh donates Smartfresh, and Stemilt assists with SmartFresh and donates and apply postharvest fungicides.

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<b>Item</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>
Salaries			
Benefits			
Wages	\$24,938.00	\$25,401.00	\$25,831.00
Benefits	\$11,375.00	\$11,396.00	\$11,407.00
RCA Room Rental	\$13,500.00	\$13,905.00	\$14,321.00
Shipping			
Supplies	\$500.00	\$500.00	\$500.00
Travel	\$500.00	\$500.00	\$500.00
Plot Fees			
Miscellaneous			
<b>Total</b>	<b>\$50,813.00</b>	<b>\$51,702.00</b>	<b>\$52,559.00</b>

**Footnotes:**

Wages/Benefits: Calculated based on expected staff wage adjustments.

RCA room rental: 1.5 rooms @ \$6500/room plus \$2500/room warehouse fees, adjusted yearly

Supplies: consumables for fruit quality lab (KOH, distilled water, iodine solution, etc.)

Travel: In-state travel

New and improved apple varieties are essential to enhance a successful Washington apple industry. The WSU apple breeding program (WABP) aims to produce a portfolio of new, improved, unique varieties, specially selected for the environment of central Washington and available to Washington's growers. Phase 3 (P3), the pre-commercialization phase of the WABP, includes larger plot plantings of the elite selections to determine potential commercial suitability. Having the WTFRC manage P3 provides an independent and industry-oriented evaluation that, with the input of industry representatives in the apple breeding program advisory committee (BPAC), ensures that the data collected, and information provided align with stakeholders' interests.

## **Objectives**

1. Evaluate and determine the commercial potential of elite selections of the WSU Apple Breeding Program (WABP)

## **Significant Findings**

Currently, there are five selections in the WABP Phase 3 (P3).

1. Selections P and L have a good shelf-life potential granted by the low incidence of disorders and diseases in the field and during storage.
2. Selection L was preferred by consumers in two pairwise tastings in spring 2022 for overall liking, texture, and flavor when compared with Honeycrisp or Cripps Pink. Preference for texture was significantly higher, outperforming both selections.
3. Selections Q, R, and S were grafted in Quincy (2020), and Sagemoor (2021), and grew to the top wire in their first year. Quality analysis of fruit from Quincy is ongoing.

## **Methods**

### ***General Procedures***

Bud and Bloom observation Field observations started as the trees began to bloom, occurring at least twice a week, considering the weather pattern and its influence on blooming. The full bloom date was determined for each P3 selection and the standard varieties near the P3 plots. Starting at this stage, every field visit includes general observations on disease incidence, tree growth habits, and health. Standard management practices (rodent activity monitoring, powdery mildew sprays, row mowing, etc.) were conducted and discussed with field managers. Pest and disease incidence and monitoring were documented during the entire season.

Fruitlet development and pre-harvest: Field activities for this stage start after June drop. Orchard visits occurred at least every other week until a month prior to predicted harvest. Observations on fruit set and self-thinning were documented. The orchard crew performed hand-thinning and summer pruning when appropriate, as if the selections were being produced commercially. In this phase, no plant growth regulator

or thinning products were applied, because we are interested in observing the natural growth and cropping of each selection.

Harvest: To determine harvest date, starch degradation is assessed in combination with color development and flavor. Once harvest date was established, harvest was conducted in one to three picks, depending on selection and crop load. From 2020 to 2022, all apple selections were strip-picked. Apples were harvested using picking bags and placed in blue crates (30 lb.).

The apples with cracks, insect damage, chemical damage, splits, severe sunburn damage, bitter pit, and birds peck are classified as culls in the field. These apples were collected during harvest and weighed separately; the reason for cullage was assessed on individual fruit, and data was used to calculate the percentage of fruit loss in the field.

The storage samples were weighed in the field and separated into two storage conditions: Refrigerated air (RA, 33°F), and controlled atmosphere (CA, 34°F 1% CO<sub>2</sub>, 2% O<sub>2</sub>), with and without 1-MCP treatment. This fruit was drenched with a postharvest fungicide at a Stemilt drencher location and stored at the Research CA rooms (RCA rooms) at Stemilt. 1-MCP treatment was administered within one week after harvest.

Quality at harvest was assessed within 48 hours of harvest using starch degradation (Cornell 1-8), firmness (lb.), soluble solids (% Brix), titratable acidity (% m.a.), color (% of red coverage and background color), size (in.), weight (gr.), and presence/absence of internal and external defects/disorders. DA index was recorded in 2022.

Post-harvest: Quality assessment takes place after 3, 6, and 8 months of storage for apples in RA, and 6 and 9 months for apples in CA. Quality analysis was conducted after 7 days at room temperature to determine the potential quality for consumers after shipping, handling and purchase. Box size distribution data was generated from individual fruit weights. Fruit flavor and eating quality were evaluated in the laboratory, by the Apple Breeding Program Advisory Committee (BPAC), and through informal consumer tasting.

### Advanced Phase 3

When a selection is considered a good contender for commercialization (typically after at least three years in P3), it will receive the following additional evaluations:

- 🍏 commercial packing line handling: glossiness and bruising will be evaluated on the same day, after 3 and 7 days in RA storage, and 3 and 7 days at room temperature.
- 🍏 formal consumer taste panels: coordinated with Kate Evans (co-PI and WSU apple breeder) and performed in locations or events with diverse consumer demographics (i.e., Spokane mall, Apple Blossom Festival). The protocol utilized was generated by Carolyn Ross (Professor and Director of the Sensory Evaluation Facility, WSU Pullman).

## Selection specific evaluations

### Selection P (Honeycrisp × Southern Snap):

- 🍏 Evaluate late harvest effect on maturity parameters, field cullage, and storage disorder incidence
- 🍏 Assess consumer preference

### Selection L (Honeycrisp × Cripps Pink):

- 🍏 establish optimum harvest window based on maturity parameters, field cullage, and storage disorders incidence
- 🍏 evaluate packing line handling (waxing and bruising)
- 🍏 assess consumer acceptance

## Results and Discussion

### Selection Q, R, and S



Q: Cripps Pink × Honeycrisp



R: Cripps Pink × WSU 3



S: Honeycrisp × WA 2

These three selections were top worked in Quincy and Sagemoor in 2020 and 2021, respectively. In Quincy, the selections are performing well, and the overall mortality rate was low; 4 trees out of 128 total trees. At the Sagemoor orchard site, all grafts of Q and R have survived, but 11 trees (out of 28) of selection S have died. Most of the trees reached the top wire within one year. Both locations were defruited in the first year, and trees from Quincy were harvested for the first time in 2022. Storage evaluation is ongoing.



Field cullage and storage disorder incidence:

Field cullage was assessed by the methods described under general procedures. Overall incidence was low, at 2.2% and 2.7% of total yield, in 2020 and 2021, respectively (data not shown). Bird peck was the main reason for cullage in both years, ranging from 0.6% to 1.9% (Figure 1). Bird peck occurrence increased over time in 2020, but not in 2021. Cracking, insect damage, sunburn, and limb rub were equal to or less than 0.5%.

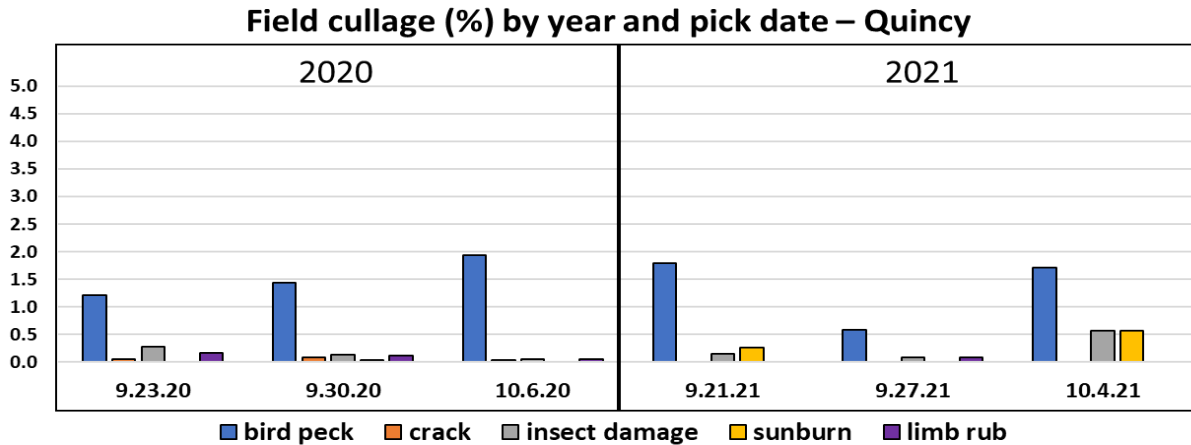


Figure 1. Percentage of field cullage caused by bird peck, cracking, insect damage, sunburn, and limb rub at harvest for selection P harvested at Quincy in 2020 and 2021 by harvest date.

Maximum stem bowl split incidence was 3% overall, combining harvest and storage. It did not increase in the latest pick of 2020 but increased by 1% in 2021 (Table 2). Greasiness was not found at harvest, but during storage, it increased slightly from the 1<sup>st</sup> to the last pick in both years, and from 2020 to 2021. The elevated incidence of greasiness in 2021 is explained by higher greasiness prevalence on fruit stored in RA without 1-MCP treatment (data not shown). Overall, greasiness is mostly slight, rather than severe. 1-MCP treatment can inhibit greasiness but is not always consistent.

Table 2. Incidence in percentage of stem bowl split (at harvest and during storage combined) and greasiness (during storage only as no greasiness was found at harvest) of selection P harvested in 2020 and 2021 by harvest sequence.

Harvest Sequence	Split (%)		Greasiness (%)	
	2020	2021	2020	2021
1st	3	1	9	20
2nd	0	1	7	21
3rd	3	2	11	24

Superficial scald, cavity, lenticel breakdown, and shrivel were not found during four years of evaluation. Watercore was found sporadically during harvest. Internal browning occurred during long-term storage on fruit from young trees (1<sup>st</sup> and 2<sup>nd</sup> leaf) at very low rates (0.2% and 0.6%). Soft scald was found

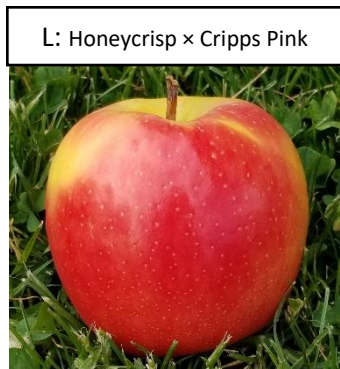
in 2020 at 0.3%. Bitter pit, stem puncture, sunburn, and russet were higher on fruit harvested from one-year-old trees. The prevalence of these disorders is less than 7%.

Based on the 2020 and 2021 results, harvesting selection P in early October did not affect fruit quality parameters, the onset of greasiness, or the incidence of other storage disorders.

#### 🍏 *Identify potential market*

Due to the Covid-19 pandemic, we were not able to perform industry tastings or a formal consumer taste panel. Some batches of fruit were evaluated by the BPAC and potential consumers. Generally, people that like tart apples enjoy selection P, and most tasters like its texture, regardless of flavor profile preferences. Assessing consumer preference is a goal for the 2023 season.

### **Selection L:**



Selection L is a bicolored apple that colors well when exposed to sunlight. It is slow to brown, easy to pick, and pre-harvest drop has not been observed. Some concerns are sensitivity to sunburn and powdery mildew (on the leaves). This selection was grafted in 2015 on both Prosser and Quincy locations. It is typically harvested from late September to early October (Golden Delicious timing).

Its unique trait is high firmness retention during storage, which, combined with the low incidence of disorders and diseases in the field and during storage, grants this selection a long shelf-life potential. Because of its desirable characteristics, selection L was moved to an advanced P3 in 2019.

#### *Selection specific evaluations*

🍏 *establish optimum harvest window based on maturity parameters, field cullage, and storage disorder incidence*

#### Maturity parameters:

Prior to 2019, color (1- 4), background color (0.5-6.0), and starch (Cornell, 1-8) were the parameters used to establish harvest timing. Consecutive picks were initiated when the average for color was at 3 (= 51 to 75% of red color coverage), background color at 4.0 (light yellow), and starch above 2.5 (Cornell, 1-8).

Selection L can maintain high levels of fruit firmness (above 20 lb.) throughout storage, sometimes resulting in apples that are perceived as too hard to eat. Starting in 2020, in addition to the above-mentioned parameters, firmness was monitored pre-harvest, and harvest began when firmness averaged 20 lb. (Figure 2). Although fruit was harvested with advanced starch (above Cornell 5) from 2020 to 2022, fruit firmness was stable during storage, decreasing only 1 to 2 lb. after 6 or 9 months of storage (data not shown).



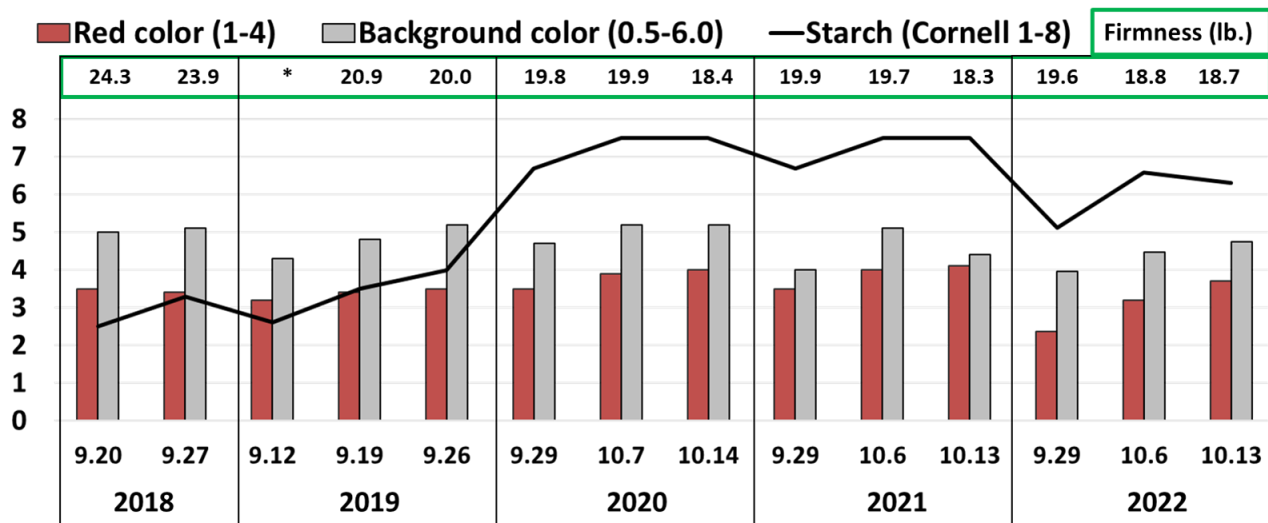


Figure 2. Color (1 = 0 to 25%, 26 to 50%, 3 = 51 to 75%, 76 to 100%) background color (0.5 to 3.5 = shades of green, 4.0 = light yellow/break, 4.5 to 5.0 = shades of yellow, 5.5 = orange, 6.0 pink/red) starch (Cornell starch scale, 1 to 8), and firmness (lb.) at harvest from 2018 to 2022 for selection L from Prosser.

Field cullage and storage disorders:

Field cullage was assessed by the methods described under general procedures. In five years of evaluation, field cullage ranged from 0.2% to 4%, and 1% to 6% in Quincy and Prosser, respectively. In Prosser, sunburn was the main reason for cullage prior to sunburn protectant applications. From 2019 forward, bird peck was the main reason for cullage on both sites (0.6% to 3.2%). The increase in the incidence of this defect is associated with the shift in harvest dates, from mid and late September to late September and mid-October.

Sunburn can be a concern because the apples need to be exposed to sunlight to develop good color coverage. However, sunburn mitigation techniques (overhead cooling in Quincy, chemical sprays in Prosser) had positive results in suppressing sunburn. Prosser has a higher incidence of sunburn (max. of 24% in 2018) due to the higher sunlight exposure provided by the tree training system. There, application of sunburn protectants was able to suppress severe sunburn damage by 1.2 to 2.4% (data not shown). Mild sunburn incidence oscillates annually, 5% to 20% in Prosser and 2% to 10% in Quincy. This type of sunburn typically colors over and might not be visible during storage.

Fungal disease and storage disorder incidence are low in this selection. No superficial scald, internal browning, or cavity was found during six years of evaluations. Soft scald has been observed mostly from Prosser on the last pick (maximum incidence of 3.2% in 2017) but does not occur every year. Russet is common but mostly located in the stem bowl (data not shown).

Lenticel breakdown was found for the first time in 2021, in only one lot (Prosser, 1<sup>st</sup> pick, CA). This fruit had lenticel markings at harvest, probably caused by heat exposure. An experiment was conducted to assess lenticel breakdown susceptibility, in which fruit was washed with organic wash or dish soap and left at room temperature (72°F) for 7 days (Figure 3). The symptoms started to appear after 3 days at room temperature. After 7 days, lenticel breakdown incidence was 9% for apples washed

with organic wash, and 56% for fruit washed with dish soap. The results indicate that even though the fruit was susceptible, the onset of symptoms can be controlled.

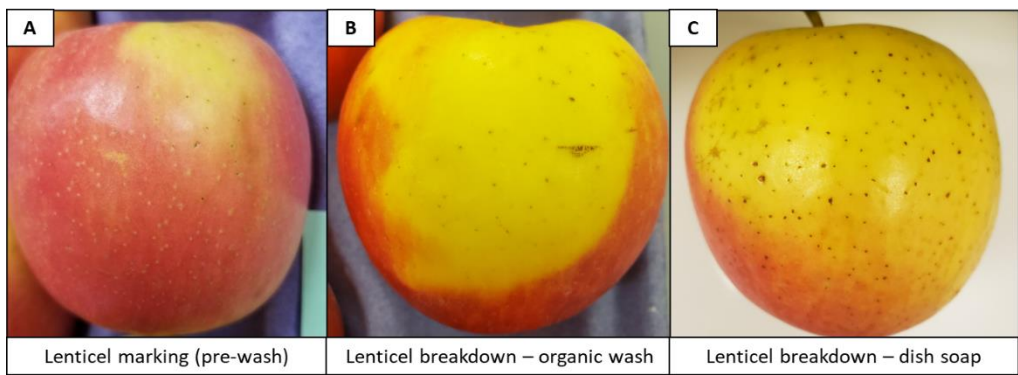


Figure 3. Selection L with lenticel marking before fruit wash (A), and lenticel breakdown symptoms after washing with organic wash (B) and dish soap (C) and left at room temperature (72°F) for 7 days.

Split incidence is low but increases as the apples mature. The overall incidence is up to 3.5%, but it can be higher when the fruit is harvested mid to late October (Figure 4). There is an annual variation of stem punctures and bruises; the overall range of both defects is from 0.5% to 5%. The apples are not stem-clipped at harvest. The incidence of these defects could be affected by the harvest methods; fruit is placed in 30lb. plastic crates at harvest and moved by hand in the field, during transport, storage, and quality analysis.

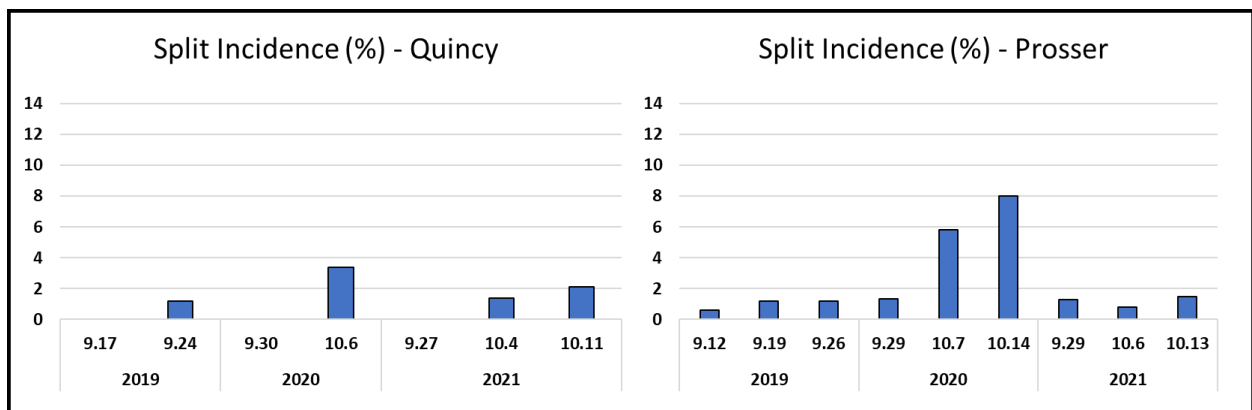


Figure 4. Percentage of split for selection L harvested at Quincy or Prosser, from 2019 to 2021.

🍏 *evaluate packing line handling (waxing and bruising)*

The COVID-19 pandemic has delayed this activity. One packing line handling evaluation was conducted in early 2020. Data collected shows that fruit can hold wax well (high gloss), only losing some of the gloss when held at room temperature for 7 days (high to medium gloss). The apples were not bruising sensitive when run over a commercial packing line.

In addition to fruit collected for quality analysis in 2022, fruit from Quincy was harvested in bins and will be used for packing line handling evaluation, including glossiness, bruising, stem puncture, decay, storage disorders, and fruit flavor.

🍏 *assess consumer acceptance*

Due to the COVID-19 pandemic, the consumer taste panels scheduled for the Spring of 2020 were canceled. Two formal consumer tastings were held in public events in 2022, with a total of 360 participants. Selection L was compared with two sets of Cripps Pink and one set of Honeycrisp apples (Figure 5). The standard selections were donated from local packing houses, and fruit quality reflects what would be available in the market at that time.

The fruit sampled in Yakima was Cripps Pink (premium) stored in CA and treated with 1-MCP, and selection L stored in CA. For the Wenatchee event, the samples were Cripps pink (WA extra fancy) stored in CA, Honeycrisp stored in CA and 1-MCP treated, and selection L stored in RA.

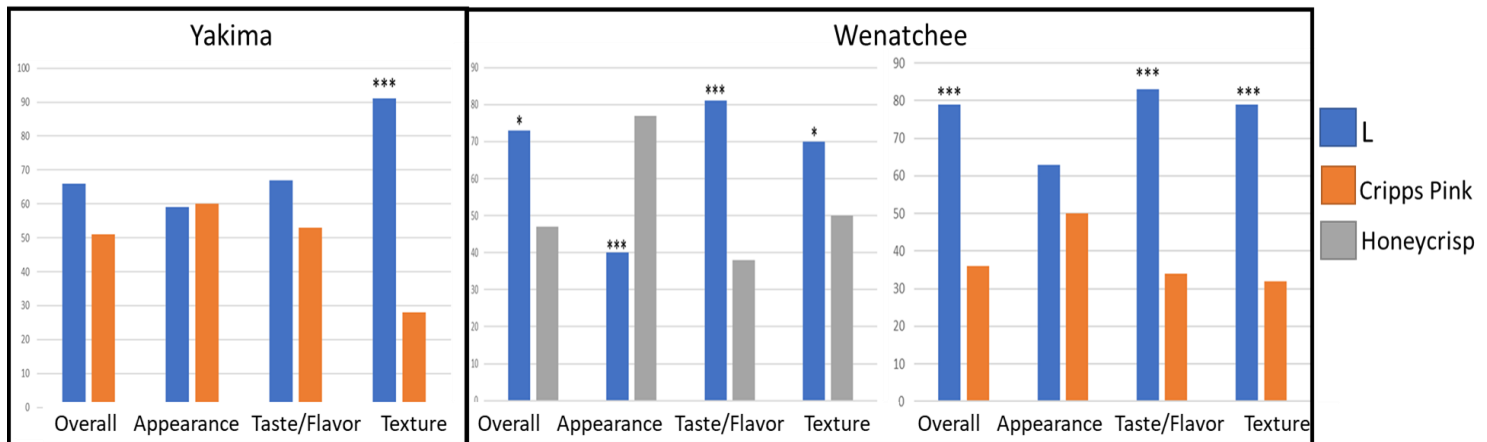


Figure 5. Results from consumer taste panels held in Yakima and Wenatchee. Selection L was compared with Cripps Pink or Honeycrisp for overall liking, appearance, taste/flavor, and texture. Comparisons with \* are significantly different (\*  $p \leq 0.05$ , \*\*\* $p < 0.01$ ).

In Yakima, selection L scored higher than Cripps Pink for overall liking, taste/flavor, and texture, but only texture was statistically significantly higher (\*\*\* $p < 0.01$ ). In Wenatchee, Selection L scored significantly higher (\*\*\* $p < 0.01$ , \*  $p \leq 0.05$ ) than Cripps Pink and Honeycrisp for all traits, except appearance. Overall selection L is preferred for texture and flavor when compared with Honeycrisp or Cripps Pink. The texture was significantly preferred on all comparison sets.

BPAC meetings and field visits: The goal of these events is to receive input on any field practices that should be taken into consideration, based on growth habits and crop load characteristics of each selection, to keep industry representatives aware of the current state of each P3 selection, and to keep this phase moving forward, based on industry-oriented recommendations. Due to the pandemic, no field events were held in 2020 and 2021. The BPAC meeting was held via ZOOM in July, and fruit samples were sent to each member up to 2 weeks prior to the meeting.

In 2022, one field visit was held in Prosser and Quincy prior to harvest. The BPAC members also had the opportunity to visit the WSDA plantings of Selection L at Sunrise and Roza research stations. The BPAC meeting occurred in August in a hybrid format. Samples were available for tasting.

## **Project Title:** Phase 3 Evaluations of Apple Breeding Program Selections

### *Executive summary*

Keywords: apple breeding, new apple varieties,

### **Abstract**

Currently, there are five selections in the WABP Phase 3 (P3). Selection Q, R, and S were top worked in Quincy and Sagemoor in 2020 and 2021, respectively. Both locations were defruited in the first year, and trees from Quincy were harvested for the first time in 2022. Storage evaluation is ongoing. Selection P is a bicolored apple, crispy, juicy, and with a unique tart-sweet flavor. It has a low incidence of field and storage disorders. Selection L is a bicolored apple that colors well when exposed to sunlight. It is slow to brown, easy to pick, and pre-harvest drop have not been observed. Its unique trait is high firmness retention during storage, which, combined with the low incidence of disorders and diseases in the field and during storage, grants this selection a long shelf-life potential. Two formal consumer tastings were held in public events in 2022, with a total of 360 participants. Selection L was compared with Cripps Pink and Honeycrisp apples. Overall, selection L is preferred for texture and flavor when compared with Honeycrisp or Cripps Pink. The texture was significantly preferred on all comparison sets.

### **Methods**

The general methods are to determine the full bloom date, perform observations twice a month during the growing season and twice a week visits pre-harvest to evaluate tree growth habits and crop load, perform a minimum of two sequential picks/selection, store fruit under commercial conditions (w/o 1-MCP) in RA & CA (1% carbon dioxide, 2% oxygen; up to 10 months), perform fruit quality and cull analysis (in the field and after storage), determine the size profile, and organize fruit tastings (formal and informal). Specific evaluations are conducted based on each selection's unique characteristics.

### **Project Outcomes**

1. In Quincy, selection P was typically harvested in mid to late September (Honeycrisp timing). Harvesting this selection in early October for two consecutive years did not negatively impact fruit quality, flavor, or storage disorder incidence.
2. Selection L has performed consistently well during 5 years of evaluations. It has a low incidence of field and storage disorders, and firmness is stable during long term-storage, granting this selection a long-shelf life potential.

### **Significant findings**

1. Selections P and L have a good shelf-life potential granted by the low incidence of disorders and diseases in the field and during storage.
2. Selection L was preferred by consumers in two pairwise tastings in spring 2022 for overall liking, texture, and flavor when compared with Honeycrisp or Cripps Pink. Preference for texture was significantly higher, outperforming both selections.
3. Selections Q, R, and S were grafted in Quincy (2020), and Sagemoor (2021) and grew to the top wire in their first year. Quality analysis of fruit from Quincy is ongoing.

### **Future work**

1. Determine fruit quality, yield, and storability of selections Q, R, and S.
2. Assess consumer acceptance and crop load management of Selection P.
3. Evaluate fruit set and packing line handling of Selection L.