FINAL PROJECT REPORT AP-18-105

Project Title: Apple scion breeding program

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Cooperators: Bruce Barritt, Professor Emeritus, WSU; Amit Dhingra, Dorrie Main, Carolyn Ross, WSU Pullman; Ines Hanrahan, WTFRC; Manoella Mendoza, WTFRC; Brett Adams, Willow Drive Nursery, Ephrata; Craig Hardner, Australian Crop Genetic Services, Brisbane, Australia

Total Project Request: Year 1: $268,142 no-cost extension granted

Other funding sources

Agency Name: USDA-CSREES Specialty Crops Research Initiative
Amount awarded: $2.7M (2014-2019)
Notes: "Genome Database for Rosaceae: Empowering Specialty Crop Research through Big-Data Driven Discovery and Application in Breeding" PI: Main. Co-PIs: Evans, Peace et al. Synergistic project for application of bioinformatics to tree fruit crops.

Agency Name: WTFRC Apple Review
Amount requested: $107,000 (2015-2018 with no cost extension)
Notes: "Combining fire blight resistance and horticultural quality in Washington apples" PI: Norelli. Co-PI: Evans. Synergistic project to identify sources of fire blight resistance.

Agency Name: USDA-CSREES Specialty Crops Research Initiative
Amount awarded: $10.0M (2014-2019)
Notes: "RosBREED: Combining disease resistance with horticultural quality in new rosaceous cultivars" PI: Iezzoni. Co-PIs: Peace, Evans et al. To further develop MAB for U.S. Rosaceae crops.

Total Project Funding:

WTFRC Budget:

Item	**2018**		
Salaries[1]	10,935		
Benefits	3,609		
Wages[2]	15,000		
Benefits	5,000		
RCA Room Rental[3]	12,600		
Shipping	---		
Supplies[4]	500		
Travel	500		
Total	**48,144**		

Footnotes:

[1]Estimate of percent of time spent for Mendoza (10%) and Hanrahan (6%), a 33% benefit rate and 2% annual increases.

[2]Based on expected staff wage adjustments proportional to the WA state minimum wage increases (2018=$11.50, 2019=$12.00, 2010=$13.50)

[3]2 rooms @ $6,300 p.a.

[4]Consumables for fruit quality lab (KOH, distilled water, iodine solution etc.)

[5]In-state travel for Hanrahan (mainly lodging in Wenatchee)

Budget 1

Organization Name: TFREC-WSU **Contract Administrator:** Shelli Tompkins

Telephone: 509 293 8803 **Email address:** shelli.tompkins@wsu.edu

Item	**2018**		
Salaries[1]	64,469		
Benefits	25,629		
Wages[2]	24,381		
Benefits	2,309		
Orchard establishment supplies	20,000		
Genotyping supplies	20,000		
Travel[3]	13,910		
Miscellaneous (virus testing)	3,000		
Plot Fees	8,800		
Total	**182,498**		

Footnotes:

[1]Salaries for Agricultural Research Technologist (Bonnie Schonberg@ 1.0 FTE) and for 3 months for genetic screening technician (to be appointed @ 0.25FTE)

[2]Wages for time-slip labor for orchard management and trait phenotyping

[3]In-state travel to research plots which are spread across the state.

Budget 2

Organization Name: Willow Drive **Contract Administrator:** Brett Adams

Telephone: 509 787 1555 **Email address:** brett@willowdrive.com

Item	**2018**		
Seedling propagation	32,500		
Phase 2 & 3 trees	5,000		
Total	**37,500**		

OBJECTIVES

1. Produce, through integration of traditional and DNA-informed breeding methods, promising selections and subsequently elite selections with outstanding eating quality and productivity.
2. Use an effective phenotypic evaluation system combined with advanced statistical analyses to identify selections with outstanding performance.

SIGNIFICANT FINDINGS

1. Twenty-two new families were made in 2018 with approximately 70,000 seeds produced in the WSU Apple Breeding Program (WABP).
2. Seedlings from approximately 14,500 seeds from 2017 crosses were grown in the greenhouse.
3. Approximately 8,000 seedlings were screened with DNA markers for fruit quality; almost 4800 were culled leaving the remaining seedlings to be transplanted to Willow Drive nursery.
4. Approximately 3,400 seedlings were screened for resistance to fire blight in the greenhouse; almost 70% survived and were transplanted to the orchard for a second inoculation.
5. Seedlings at Willow Drive were propagated on M.9 rootstocks for future orchard evaluation. Approximately 3,000 seedling/M.9 trees were produced in the nursery for planting in Phase 1 seedling orchards in 2019.
6. The final count of new Phase 1 trees planted in 2018 was approximately 2,250.
7. Promising selections already in Phase 2 trials (planted in 2007-2017) at three evaluation sites in Central Washington were evaluated for productivity and fruit quality.
8. Twenty-two new promising selections (on Geneva 41 rootstock) were planted at three evaluation sites in Phase 2 trials in 2018.
9. Fifteen promising selections made in 2017 were propagated in 2018 for planting in 2020 Phase 2 trials at three diverse sites in Central Washington.
10. Fruit was harvested and evaluated through storage for three Phase 3 selections.
11. One Phase 3 selection was discontinued, and one is advancing within Phase 3 in accordance to BPAC advice to the program.

RESULTS & DISCUSSION

Objective 1: Produce, through integration of traditional and DNA-informed breeding methods, promising selections and subsequently elite selections with outstanding eating quality and productivity.

Crosses for this season were designed taking into account all the available DNA test information as well as phenotypic trait knowledge. DNA testing focused on the Ma-indel test (acidity, crispness, bitter pit resistance) and worked very efficiently to reduce population sizes. In addition, five progenies were screened with the LG8a acidity test, one with the Md-LG1Fru-SSR test for fructose content and two for the Md-ACS1-indel storage/firmness test.

Approximately 3,400 seedlings were screened in the greenhouse for resistance to fire blight. These seedlings were the result of crosses combining fire blight resistance from the cultivars Fiesta and Splendour (both with known resistances) with three fire blight resistant WABP selections. The total survival rate was almost 70% indicating an overall increase in resistance from earlier crossing generations. Resistant individuals were planted in the Columbia View orchard and re-inoculated later in the season.

Stored fruit from the 2018 harvest is still being evaluated for fruit quality and storage potential.

Twenty-two new Phase 2 selections were planted at the WSU Columbia View orchard in spring 2018. This has re-established Phase 2 at CV, following several years of planting at WSU Sunrise orchard, to consolidate operations following the hiring of a new farm worker at CV using WA 38 royalty income.

Objective 2: Use an effective phenotypic evaluation system combined with advanced statistical analyses to identify selections with outstanding performance.

Performance data will be analyzed at the end of the season with 'Elite Advance' software, trait by trait, and top-ranking individuals will be selected using a combination of this data and breeding team discussion.

Fruit was harvested from four elite selections in Phase 3 from the Quincy site (three from the Prosser site).

Fruit evaluations in Phase 3 include field observation and horticultural management. All activities are guided by the BPAC. Apples harvested from Phase 3 plantings were drenched with a post-harvest fungicide, tested with and without a 1-MCP treatment and stored in regular and controlled-atmosphere storage using the Stemilt RCA facility. Fruit collected at harvest was tested in the WTFRC lab as well as the TFREC lab; WTFRC evaluates long term storage.

- The two selections planted in 2017 will continue in Phase 3 for further evaluation
- One of the selections planted in 2015 was discontinued due to major flaws in its long-term storage performance (high incidence of internal browning, softening, inconsistent flavor)
- The second selection planted in 2015 was advanced within P3, due to its consistent flavor profile, annual bearing, fruit size profile, and high-performance during storage (fruit maintains its quality for up to ten months, potentially one year). In addition to field evaluations and quality parameters analysis already mentioned, this apple will be evaluated on at the packing line (bruising incidence and wax quality) and in a consumer taste panel during the upcoming storage season (2019-20).

Thanks to Dave Allan and Sarah Franco in Prosser, Scott Driscoll and Dale Goldy in Quincy for horticultural management assistance and Ray Fuller for maintaining the Phase 2 planting in Chelan. Also, thanks to AgroFresh for providing 1-MCP, Stemilt for accommodating our complex needs through the storage season and to Legacy Fruit packers.

WABP Publicity (March 2018-March 2019)

WA 38 and breeding program coverage included in the following:

NWPB (Nov 2018) https://www.nwpb.org/2018/11/26/like-that-year-round-crisp-apple-thank-a-scientist-or-warehouse-possibly-in-wenatchee

KSPS (Nov 2018) https://youtu.be/Uzg9MjlVTtY

Produce Business Journal (August 2018) A star is born

Good Fruit Grower (June 2018) Post-Cosmic question: What's next?

The Produce News (June 2018) Exciting research from Pace International's record-breaking Postharvest Academy

Wenatchee World (June 2018) Big impacts

KCTS9 (June 2018) Washington's new apple could be an industry game-changer

Fresh plaza (May 2018) Working as a state for Cosmic Crisp®

Ag Info podcast (May 2018) Cosmic Crisp® exceeds expectations

Popular Science (May 2018) I developed a sturdier, crisper, and yummier apple

Capital Press (April 2018) Cosmic Crisp® plantings beat estimate

Presentations:

Feb 2018 - Omak Horticulture Day (*Hanrahan*): WA 38 fruit quality and starch scale.

Mar 2018 – Washington Farm Bureau visit. (*Evans*): 'WSU apple breeding program'.

Mar 2018 - Postharvest Fruit School (*Hanrahan*): WA 38 fruit quality and starch scale.

Apr 2018 – UC Davis Plant Breeding Seminar Series, UC Davis, CA. (*Evans*): 'Development and application of DNA-informed breeding in the WSU apple breeding program.'

May 2018 – Pace Academy (*Hanrahan*): Harvest and storage management of WA 38.

June 2018 – Korean nursery group visit. (*Evans*): 'WSU apple breeding program.'

June 2018 – IRTA/Portuguese grower visit, (*Evans*): 'Introduction to TFREC and the WSU apple breeding program.'

Sept 2018 – International New Varieties Network, Sunrise orchard field visit. (*Evans*): 'WSU pome fruit breeding program.'

Oct 2018 – International Pome Fruit Alliance visit, (*Evans*): 'WSU pome fruit breeding program.'

Dec 2018 - Washington State Tree Fruit Association (WSTFA) 114th annual meeting (*Kostick* [Evans grad student]): 'Identifying elite sources of fire blight resistance in apple.'

Dec 2018 - Washington State Tree Fruit Association (WSTFA) 114th annual meeting (*Kostick*): 'Fire blight susceptibility; apple cultivar survey.'

Dec 2018 - Washington State Tree Fruit Association (WSTFA) 114th annual meeting (*Hanrahan*): Fruit quality of WA 38.

Dec 2018 - Washington State Tree Fruit Association (WSTFA) 114th annual meeting (*Mendoza*): 'WA 38 -Resumen de actividades cosecha y postcosecha'

Peer-reviewed publications

Jung S, Lee T, Cheng C-H, Buble K, Zheng P, Yu J, Ficklin S, Gasic K, Scott K, Frank M, Ru S, Hough H, Evans K, Peace C, McFerson J, Coe M, Staton M, Wegrzyn J, Main D. (2018) 15 years of GDR: new data and functionality on the Genome Database for Rosaceae. *Nucleic Acids Research* gky1000.

Kostick S, Evans K. (2018) Apple. In: (K. Gasic, J.E. Preece, and D. Karp, eds.) Register of New Fruit and Nut Cultivars List 49. HortScience 53(6): 748-750. doi.org/HORTSCI1049fn-18.

Desnoues E, Norelli JL, Aldwinckle HS, Wisniewski ME, Evans KM, Malnoy M, Khan A (2018) Identification of novel strain-specific and environment-dependent minor QTLs linked to fire blight resistance in apples. *Plant Molecular Biology Reporter* doi.org/10.1007/s11105-018-1076-0

EXECUTIVE SUMMARY

PROJECT TITLE: Apple scion breeding program

KEY WORDS: apple breeding, new apple varieties, phenotypic evaluation

ABSTRACT: This one-year project describes in detail the progress of the Washington State University apple breeding program for the field season 2018/19.

This one-year project describes in detail the progress of the Washington State University apple breeding program for the field season 2018/19 and the no-cost extension to enable completion of the postharvest fruit evaluation. Twenty-two new families were made in 2018 with approximately 70,000 seeds produced in the WSU Apple Breeding Program (WABP), with 8,000 seedlings screened with DNA markers for fruit quality. Seedlings at Willow Drive were propagated on M.9 rootstocks for future orchard evaluation. Approximately 3,000 seedling/M.9 trees were produced in the nursery for planting in Phase 1 seedling orchards in 2019. The final count of new Phase 1 trees planted in 2018 was approximately 2,250.

Twenty-two new promising selections (on Geneva 41 rootstock) were planted at three evaluation sites in Phase 2 trials in 2018; and fifteen promising selections made in 2017 were propagated in 2018 for planting in 2020 Phase 2 trials at three diverse sites in Central Washington.

Fruit was harvested from four elite selections in Phase 3 from the Quincy site (three from the Prosser site). Fruit evaluation data was presented in further detail to the apple breeding program advisory committee in a meeting on May 24th, 2019 with follow up orchard visit to the Phase 3 planting in Quincy (repeated July 30th). A further orchard visits to both Quincy and Prosser were offered September 6th, 2019.