The National Association of Plant Breeders in partnership with the Plant Breeding Coordinating Committee and The Plant Breeding Genomics Community of Practice presents

How to breed new plant varieties: imagining and engineering crops

Kate Evans
Washington State University
Tree Fruit Research & Extension Center, Wenatchee

National Association of Plant Breeders
NAPB
Improving Plants to Improve Lives

PLANT BREEDING & GENOMICS

extension

The National Association of Plant Breeders in partnership with the Plant Breeding Coordinating Committee and The Plant Breeding Genomics Community of Practice presents

Making Appealing Apples

Kate Evans

Washington State University

Tree Fruit Research & Extension Center, Wenatchee

WASHINGTON STATE UNIVERSITY

Part I
Apple
(*Malus* × *domestica* Borkh.)

Apple background

- Rosaceae – includes almonds, peaches, cherries, apricots, plums, strawberries, blackberries, raspberries, pears, roses and other ornamentals.

- Apple has a basic chromosome number of 17 unlike most of the rest of the Rosaceae where x=7, 8 or 9

- Apple is an autopolyploid – relatively recent duplication and aneuploidization

  Velasco et al. (2010) *Nature genetics* 42: 833-839

- Apple varieties are typically diploid although triploids are relatively common

Origins of apple as a cultivated species

Malus sieversii
Kazakhstan,
central Asia

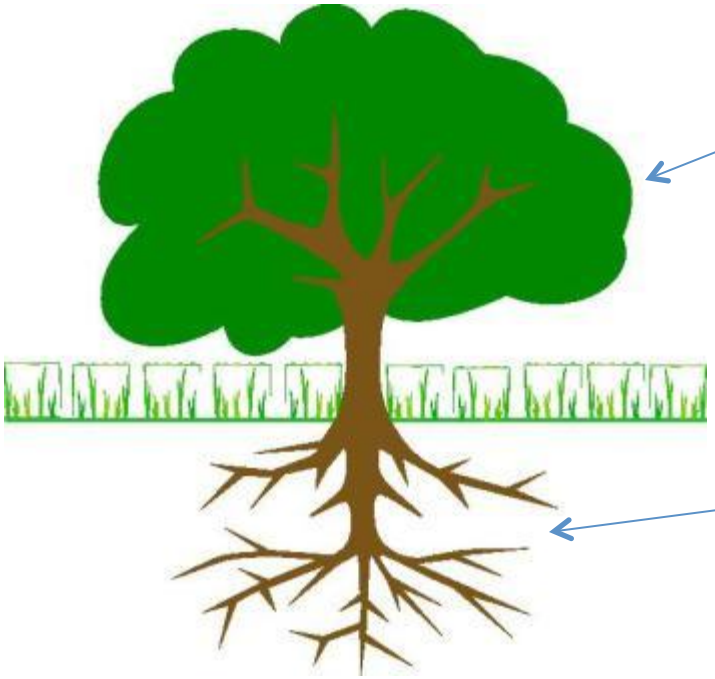
Juniper, B.E. & Mabberley, D.J., 2006. *The story of the apple*, Portland, Oregon: Timber Press.

Apple trees do not come true to type from seed

Photo by Istockphoto

Apples are vegetatively propagated

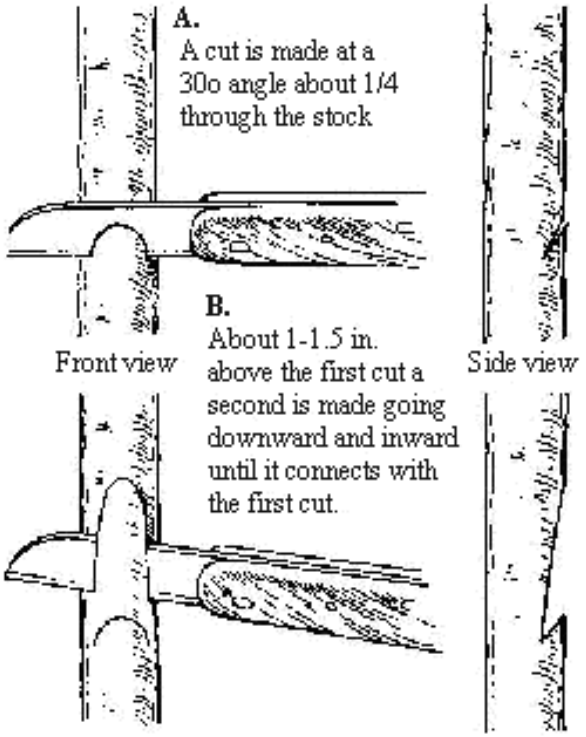
(do not come true to type from seed)



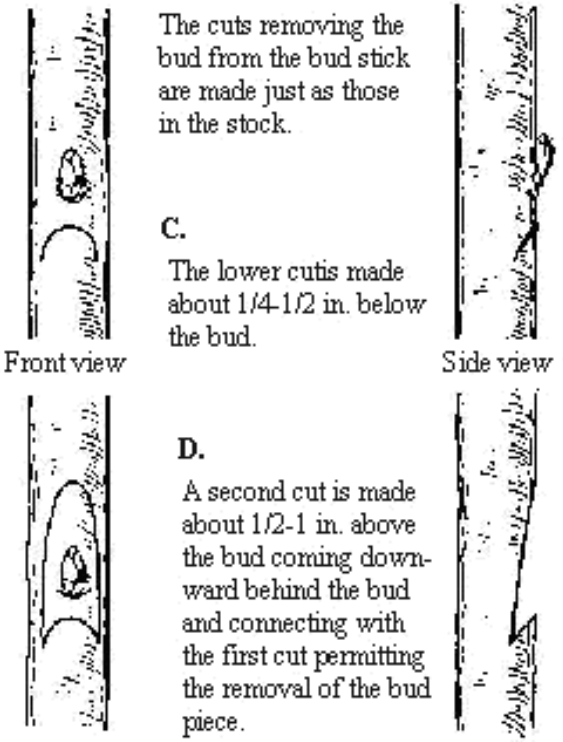
Scion:
aerial fruiting part

Rootstock:
non- fruiting part

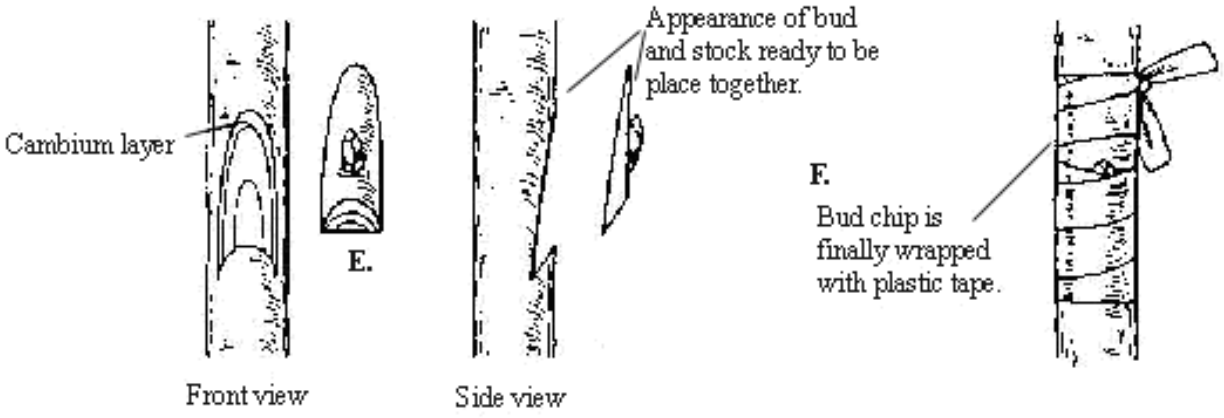
Preparing the Stock



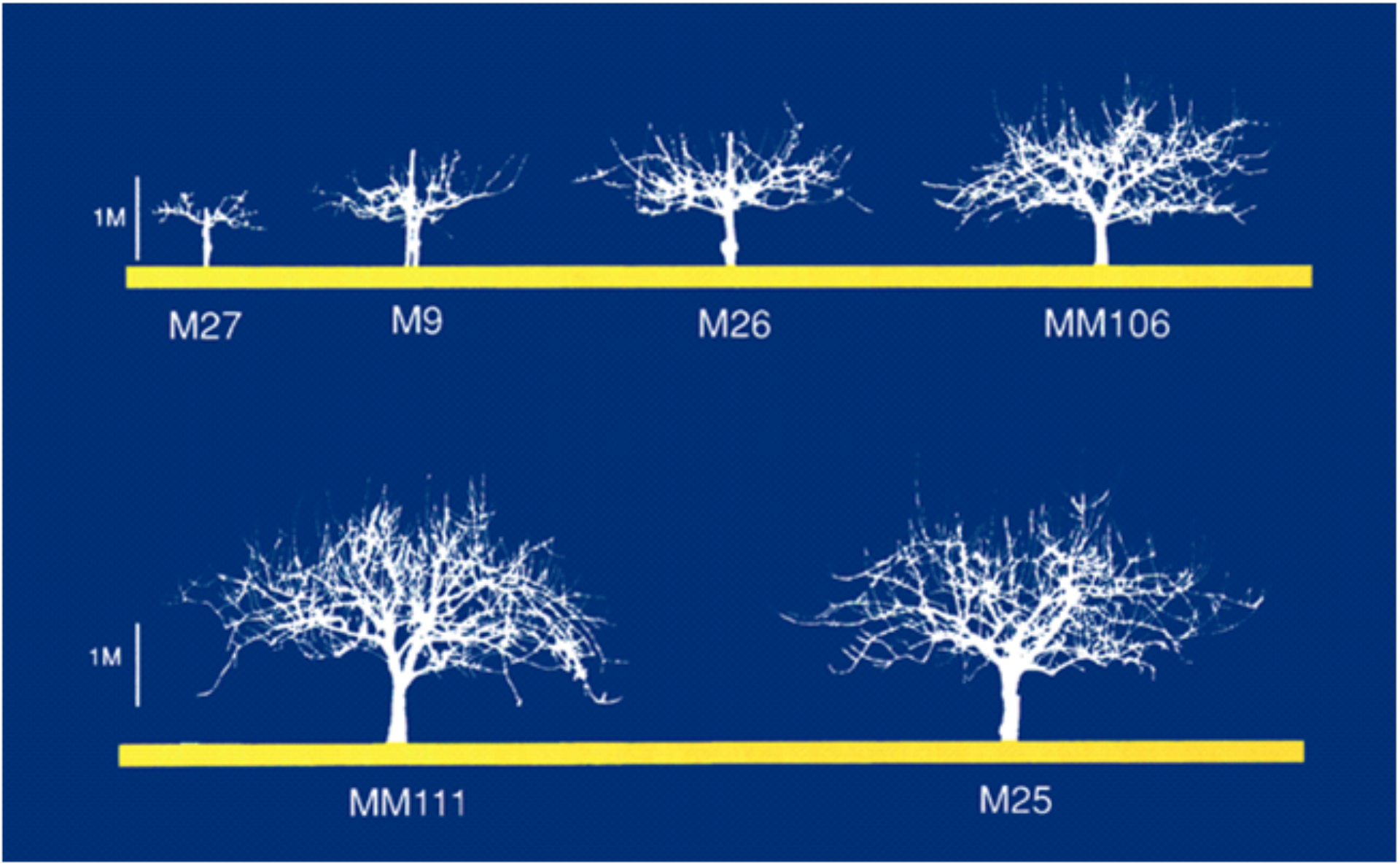
Preparing the Bud



Inserting the But Into the Stock



http://www-intranet.angers.inra.fr/dossiers/haploidie/haploeng/techsheet8.html



Rootstocks can affect many aspects of the tree, e.g. vigor, precocity

http://blogs.cornell.edu/hort/2011/03/15/seminar-video-gennaro-fazio-on-apple-rootstocks/

Apples have gametophytic self-incompatibility and are therefore out-crossers

- Pollen from variety X will not pollinate variety X
- Pollenizer varieties are needed
- >29 reported *S* alleles
- Bloom can spread over several weeks in any one location

Part II
Breeding targets & hybridization

Breeding targets

1. Fruit quality

appearance

eating quality

storability

2. Production factors

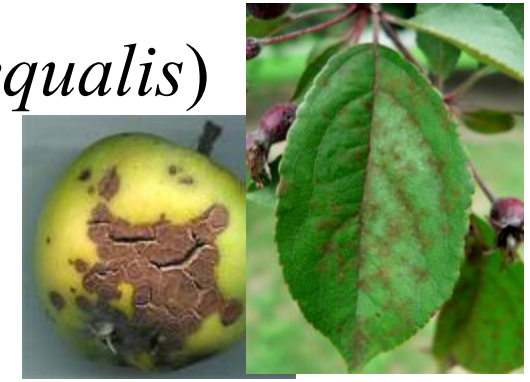
high yield

regular cropping

cold tolerance/winter chill

3. Resistances

apple scab
(*Venturia inaequalis*)

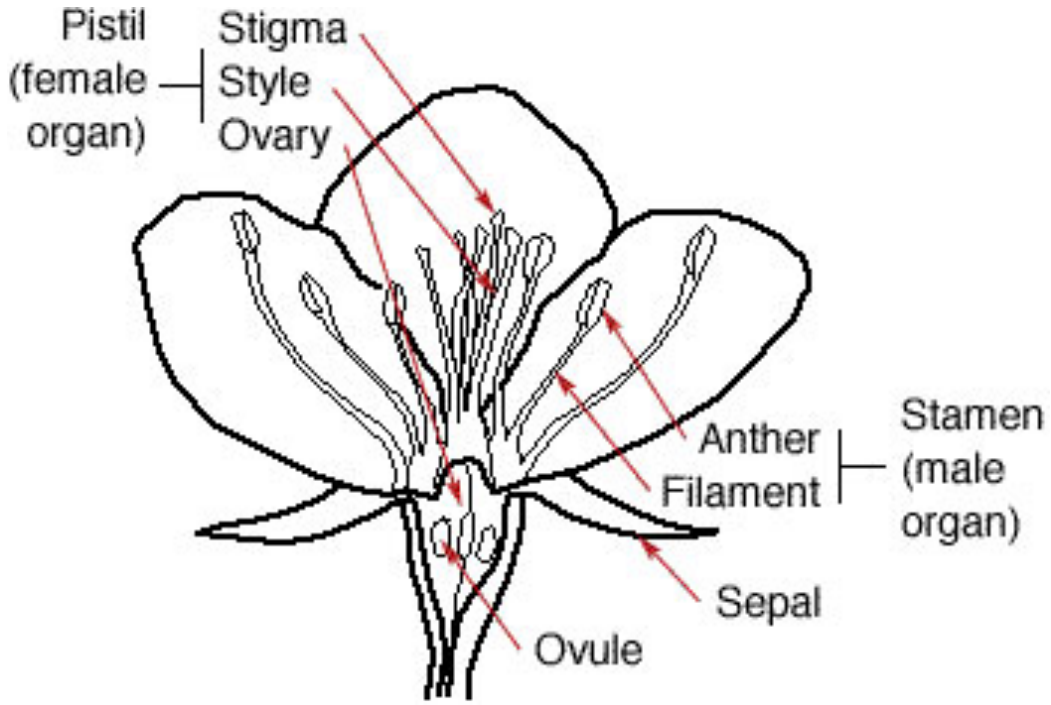


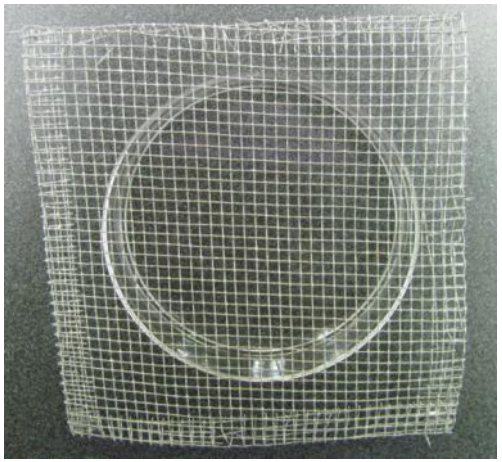
powdery mildew
(*Podosphaera leucotricha*).

sunburn

fire blight
(*Erwinia amylovora*)

Controlled hybridization





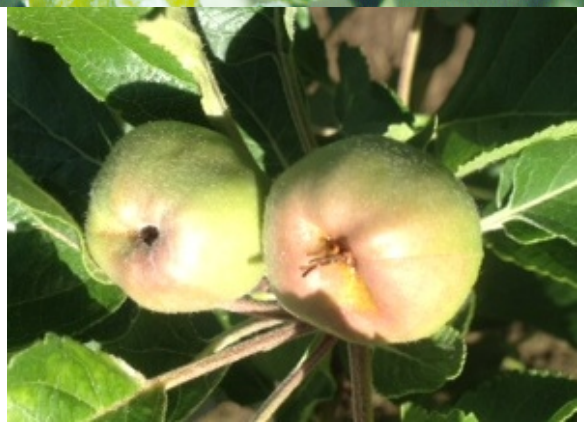


Photo: J. Norelli

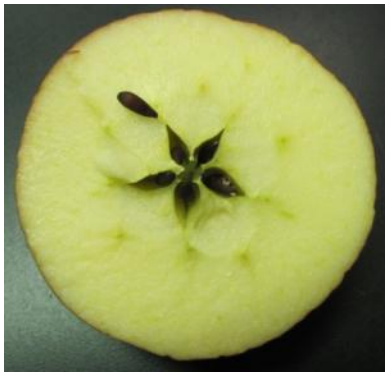


Photo: F. Fernández

Photo: J. Norelli

Part III
Apple breeding at WSU

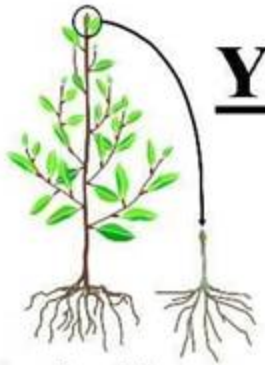
Pollination

Year 1

Hybrid Seeds

Year 2

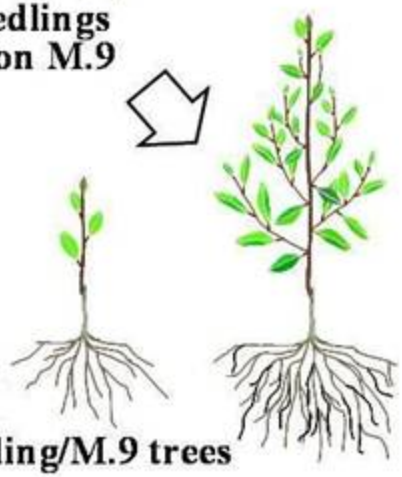
Seedlings



Year 3

2 Year Seedlings budded on M.9

Year 4



Seedling/M.9 trees

Years 5-8

Phase 1

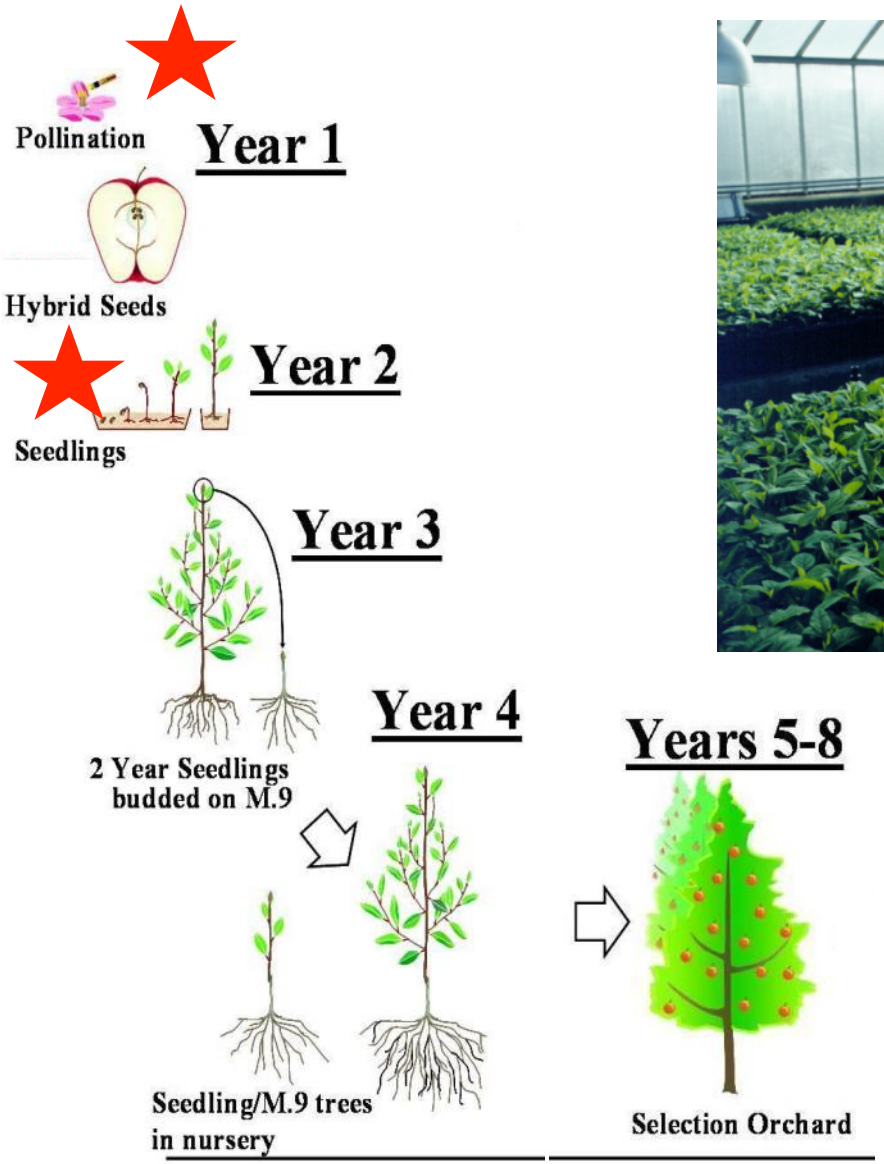
Years 9-13

Phase 2

Years 14-18

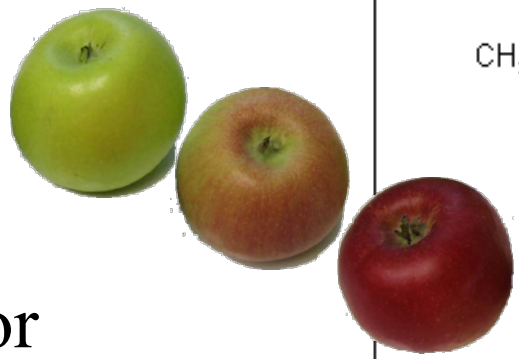
Phase 3

DNA-informed breeding at WSU

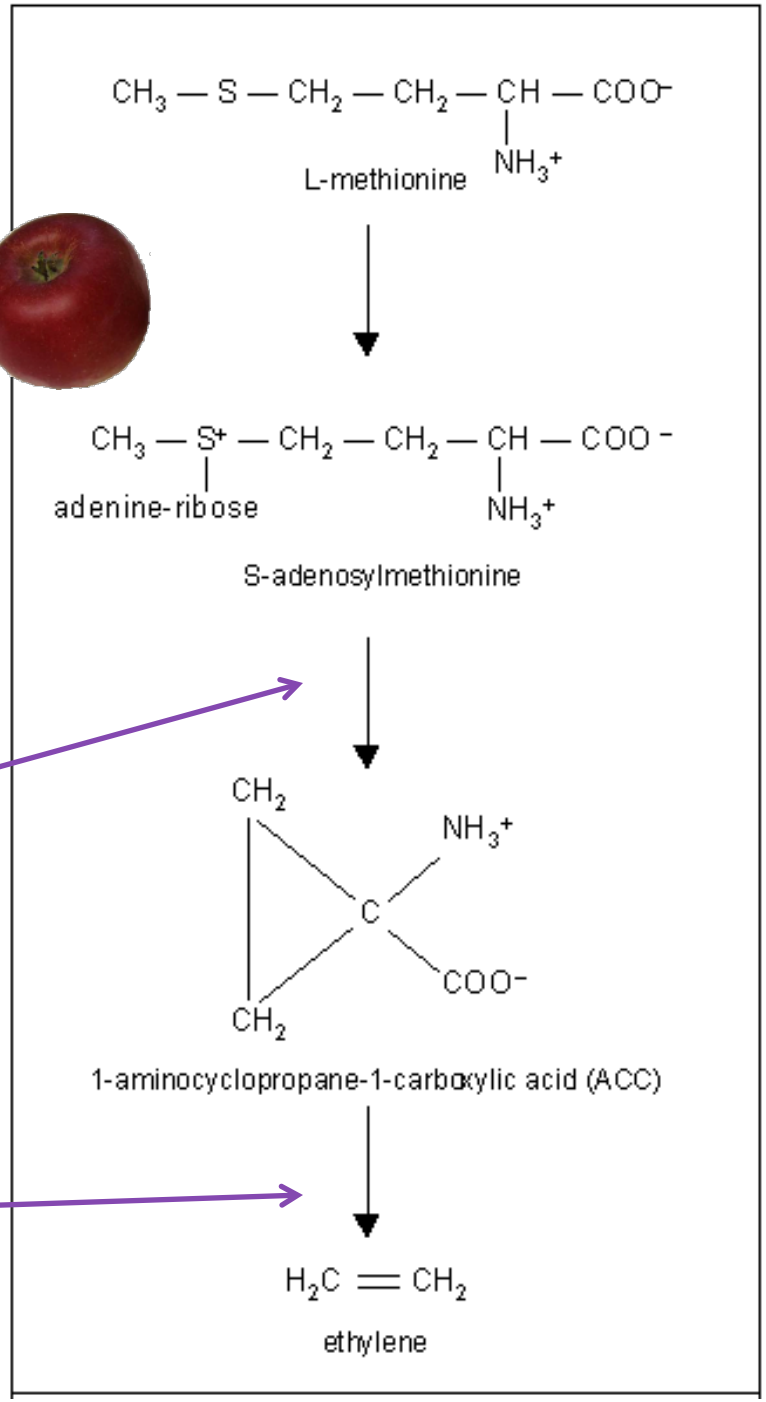


	1	2	3	4	5	6	7	8	9	10	11	12
A	1110-A01	1110-A02	1110-A03	1110-A04	1110-A05	1110-A06	1110-A07	1110-A08	1110-A09	1110-A10	1110-A11	1110-A12
	CULL	CULL	CULL	KEEP	KEEP	KEEP	CULL	KEEP	KEEP	CULL	CULL	CULL
B	1110-B01	1110-B02	1110-B03	1110-B04	1110-B05	1110-B06	1110-B07	1110-B08	1110-B09	1110-B10	1110-B11	1110-B12
	CULL	CULL	KEEP	KEEP	KEEP	CULL	CULL	CULL	CULL	KEEP	CULL	CULL
C	1110-C01	1110-C02	1110-C03	1110-C04	1110-C05	1110-C06	1110-C07	1110-C08	1110-C09	1110-C10	1110-C11	1110-C12
	KEEP	KEEP	CULL	KEEP	CULL	CULL	KEEP	KEEP	KEEP	CULL	KEEP	KEEP
D	1110-D01	1110-D02	1110-D03	1110-D04	1110-D05	1110-D06	1110-D07	1110-D08	1110-D09	1110-D10	1110-D11	1110-D12
	KEEP	CULL	KEEP	KEEP	CULL	KEEP	KEEP	KEEP	KEEP	KEEP	CULL	KEEP
E	1110-E01	1110-E02	1110-E03	1110-E04	Gala		1110-E07	1110-E08	1110-E09	1110-E10	1110-E11	1110-E12
	CULL	CULL	KEEP	CULL			CULL	CULL	CULL	KEEP	CULL	CULL
F	1110-F01	1110-F02	1110-F03	1110-F04	1110-F05	1110-F06	1110-F07	1110-F08	1110-F09	1110-F10	1110-F11	1110-F12
	KEEP	KEEP	KEEP	CULL	KEEP	CULL	KEEP	KEEP	CULL	REVIEW	KEEP	KEEP
G	1110-G01	1110-G02	1110-G03	1110-G04	1110-G05	1110-G06	1110-G07	1110-G08	1110-G09	1110-G10	1110-G11	1110-G12
	KEEP	KEEP	CULL	KEEP	KEEP	KEEP	KEEP	KEEP	KEEP	CULL	REVIEW	CULL
H	1110-H01	1110-H02	1110-H03	1110-H04	1110-H05	1110-H06	1110-H07	1110-H08	1110-H09	1110-H10	1110-H11	1110-H12
	CULL	REVIEW	KEEP	KEEP	KEEP	CULL	KEEP	CULL	REVIEW	REVIEW	KEEP	CULL

Fruit Quality Markers?



- Fruit skin color
- Ethylene regulation



ACS (ACC synthase)

ACO (ACC oxidase)

Zhu & Barritt, (2008) *Tree Genet. Genom.* 4: 555-562

RosBREED

www.rosbreed.org

Crispness, juiciness, acidity

Single sugars

USDA ARS

Phase 1: seedling evaluation

Phase 1

Currently ~24,000 trees

WASHINGTON STATE UNIVERSITY

Tree and sample management

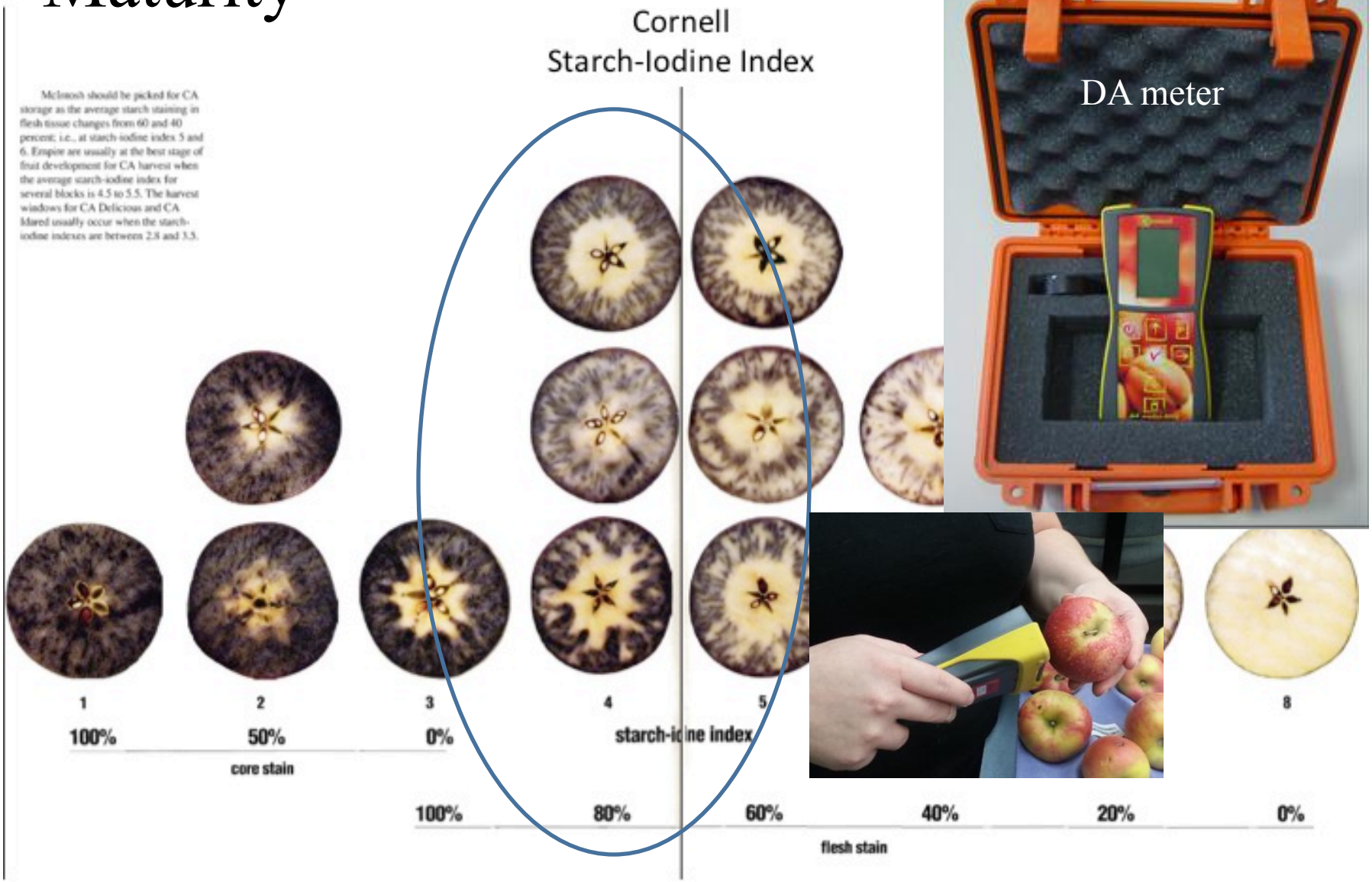
Evans et al., 2012. *HortSci* 47:149

Fruit samples

2 months cold storage
+ 1wk shelf life

WASHINGTON STATE UNIVERSITY

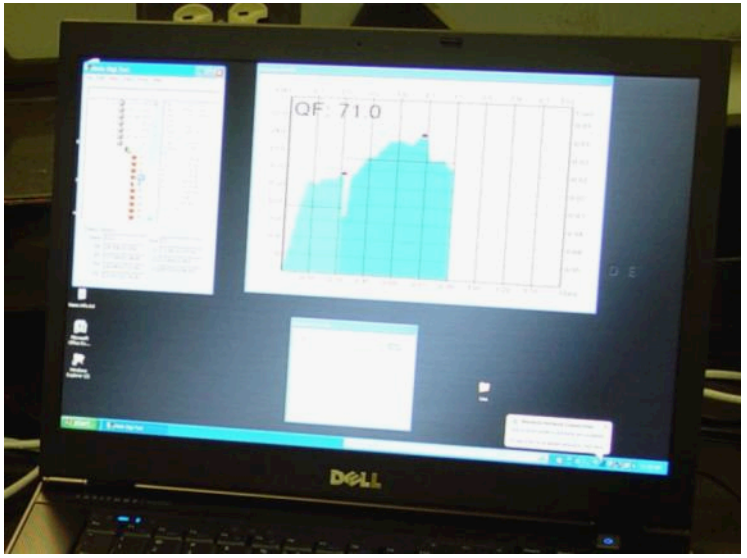
Maturity



Blanpied, G.D. and S.J. Silsby. 1992, Predicting Harvest Date Windows for Apples. Cornell Cooperative Extension. Informational Bulletin 221.

Selections – texture testing

Mohr® DigiTest

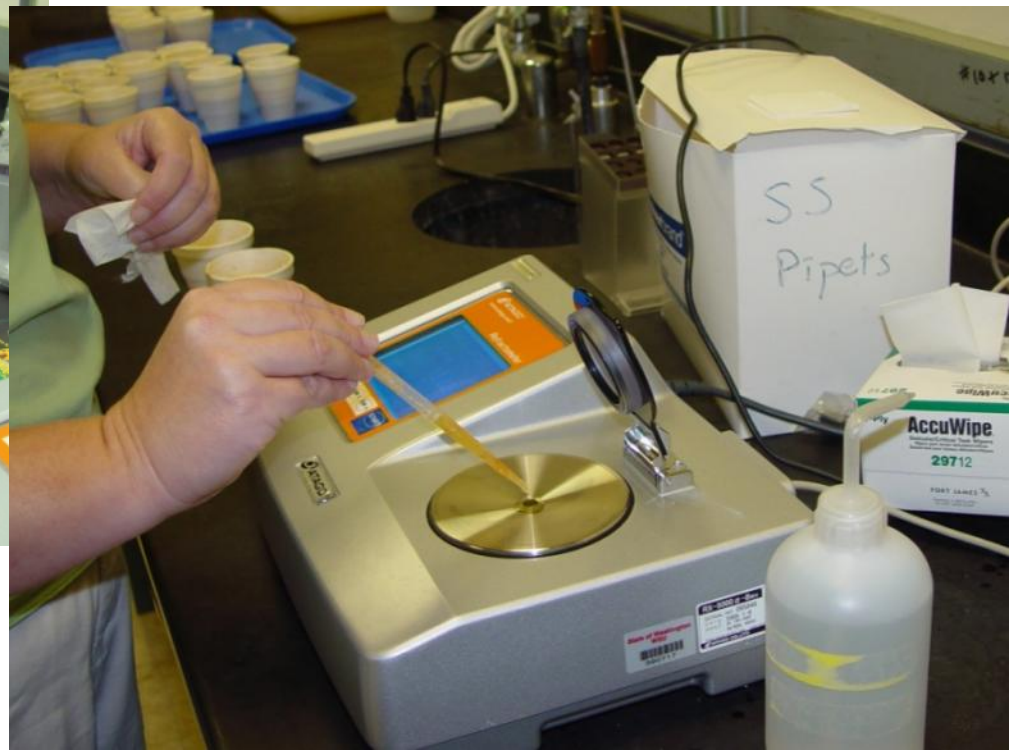


Evans et al., 2010. *HortTech* 20:1026-1029

WASHINGTON STATE UNIVERSITY

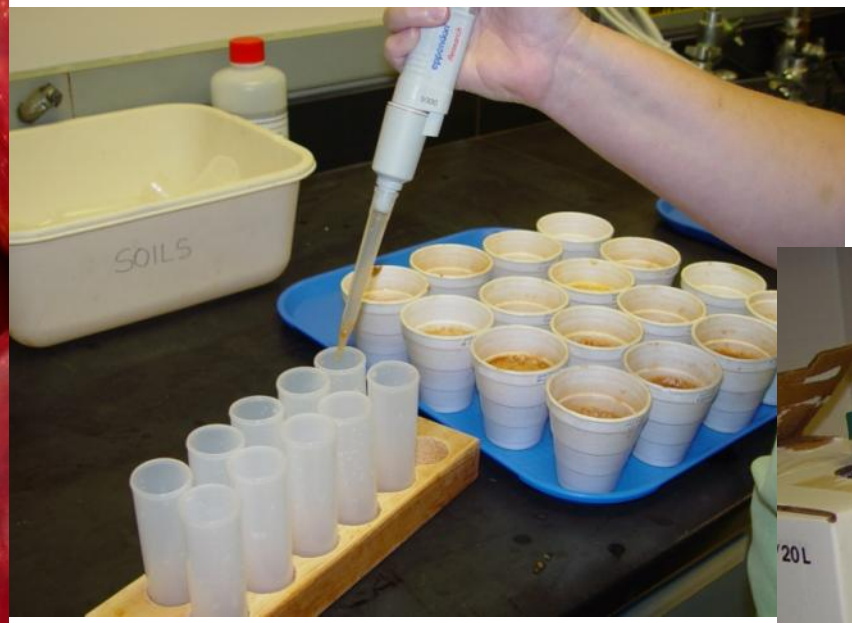
Selections – juice testing

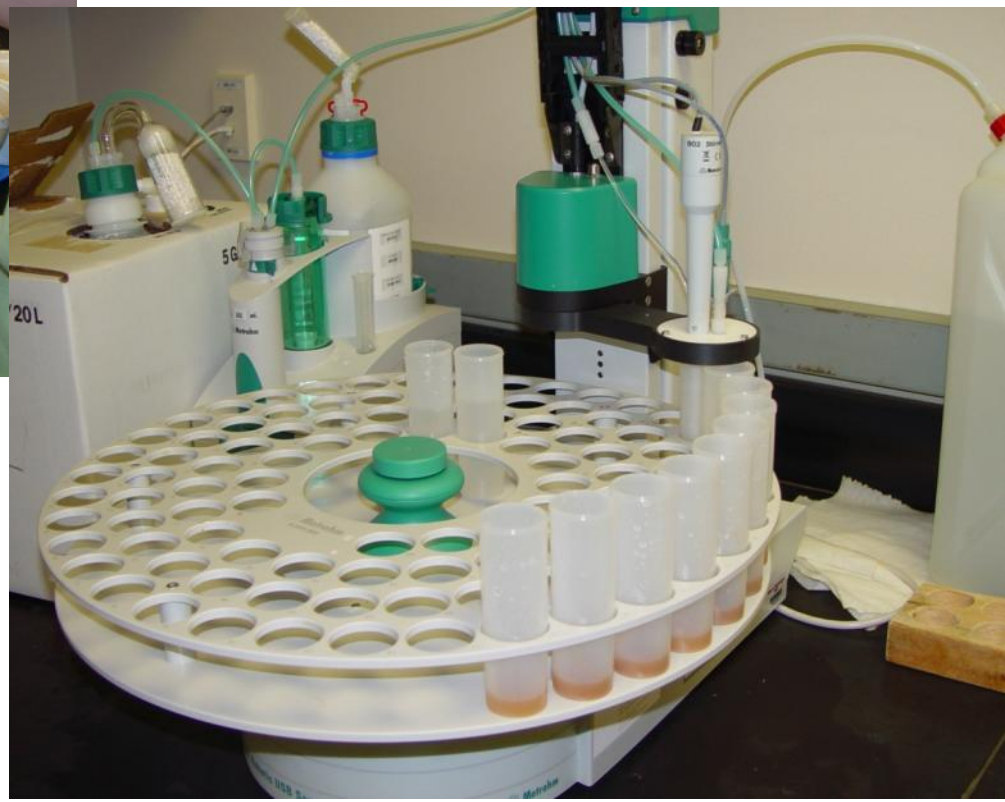
Selections – soluble solids testing



WASHINGTON STATE UNIVERSITY

Selections – acidity testing





WASHINGTON STATE UNIVERSITY

Selections – sensory testing

GDR | Genome Database for Rosaceae

Search

Logged in as: kate | Log Out

Browse database | display information about data | search database | Home | General Info | Species | Projects | Maps | Search

Tools | Community | Calendar | Contact | Kate Group | rosFORUM | Testing Modules

Home Page of WSU Apple Breeding Program

View | Edit

Page *Home Page of WSU Apple Breeding Program* has been updated.

Kate's Apple Breeder Group

- Create Calendar Event
- Create Group Document
- 6 members
- Manager: cho
- My membership

Breeding Program Outline

The Washington State University apple breeding program began in 1994 to develop new varieties suitable to the unique climate of central Washington. Washington is the leading apple producing state with over 50% of U.S. production. Unfortunately, many of the new varieties developed in the world are not well adapted to growing conditions in central Washington or available to the majority of Washington growers.

The goal is to produce apples of a high eating quality with particular factors of outstanding flavor, texture and juiciness. The breeding program is a traditional breeding program, hybridizing parents with desirable traits. Promising seedlings are selected from large populations and their fruit is evaluated in the laboratory for eating quality and suitability for long-term storage. This program is one of the 12 core US breeding programs of the SCRI RosBREED project, enabling the application of marker-assisted breeding within the 4 years of the project.

The first release from the program, 'WA 2', was offered to Washington State growers for evaluation in December 2009. Several other elite selections have been planted in commercial grower trials in central Washington.

Screenshot

Groups: Kate's Apple Breeder Group

Washington State University

Funded by the 2009 USDA NIFA Specialty Crop Research Initiative Program

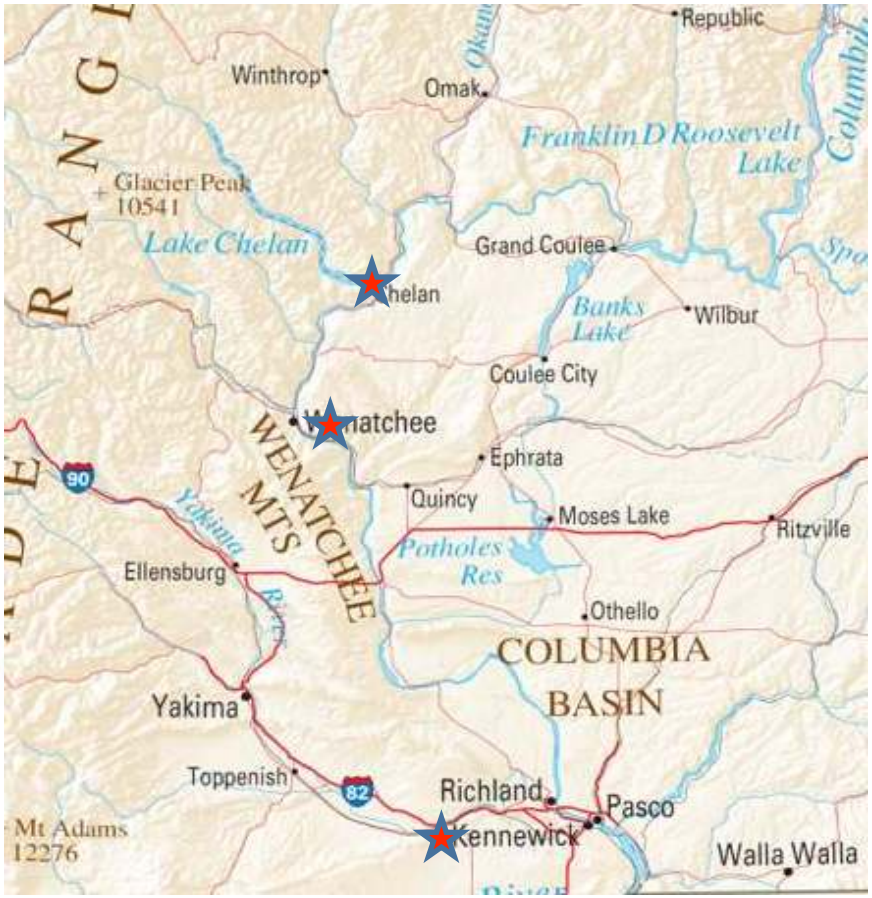
Clemson University

Breeding program database

Evans et al., (2014) *Database* DOI 10.1093/database/bat078

Phase 2: Small scale multi-site on-farm trials

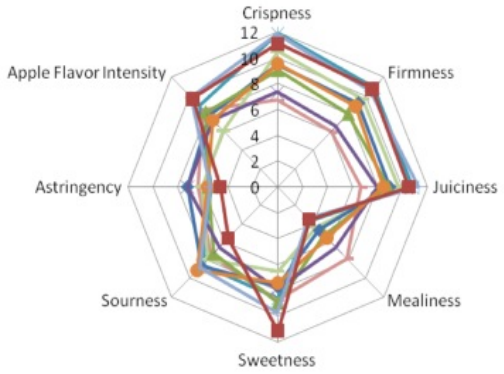
Phase 2



- Randomized blocks with 5 replicates
- Standard control varieties
- 3 Sites (~160 miles/255km N to S)
- >40 advanced selections
- Multiple pick dates
- Test after 2 & 4 months cold storage + 1wk shelf-life

WASHINGTON STATE UNIVERSITY

Sensory profiling/ Consumer tests

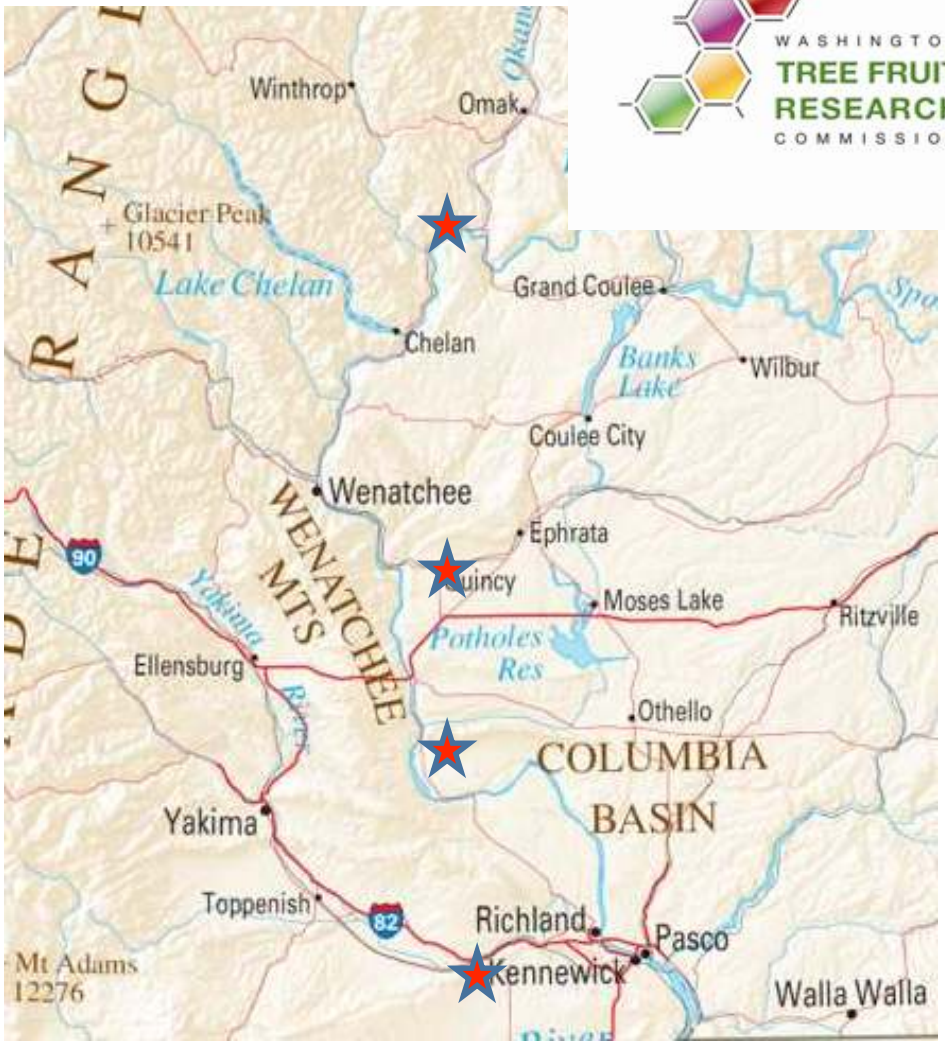


Phase 3: Mid scale multi-site on-farm trials

Phase 3

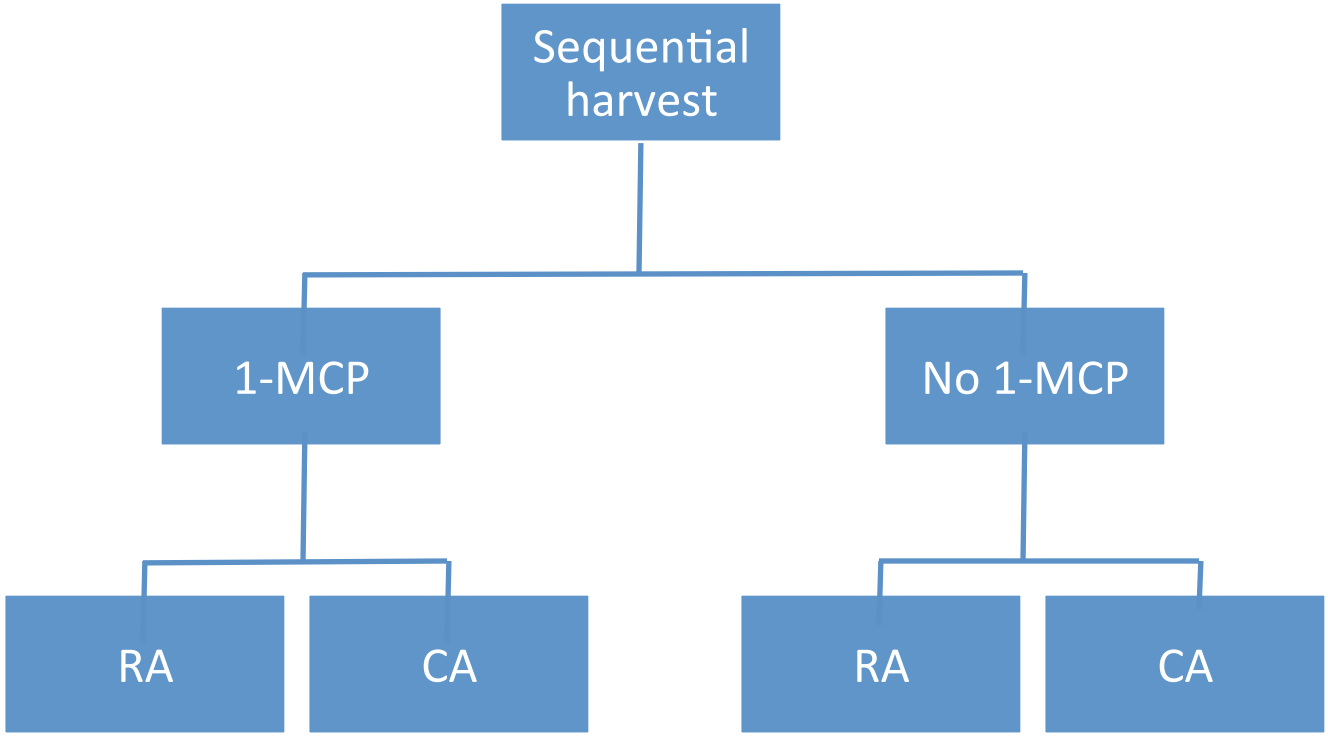
- Approx 75 trees per selection
- 4 Sites

Produces a large volume of fruit!



WASHINGTON TREE FRUIT RESEARCH COMMISSION

Harvest and storage assessments



RA: Regular Atmosphere storage
CA: Controlled Atmosphere storage (O_2/CO_2 ratio controlled)
1-MCP: 1-Methylcyclopropene (blocks ethylene receptors)

WASHINGTON TREE FRUIT RESEARCH COMMISSION

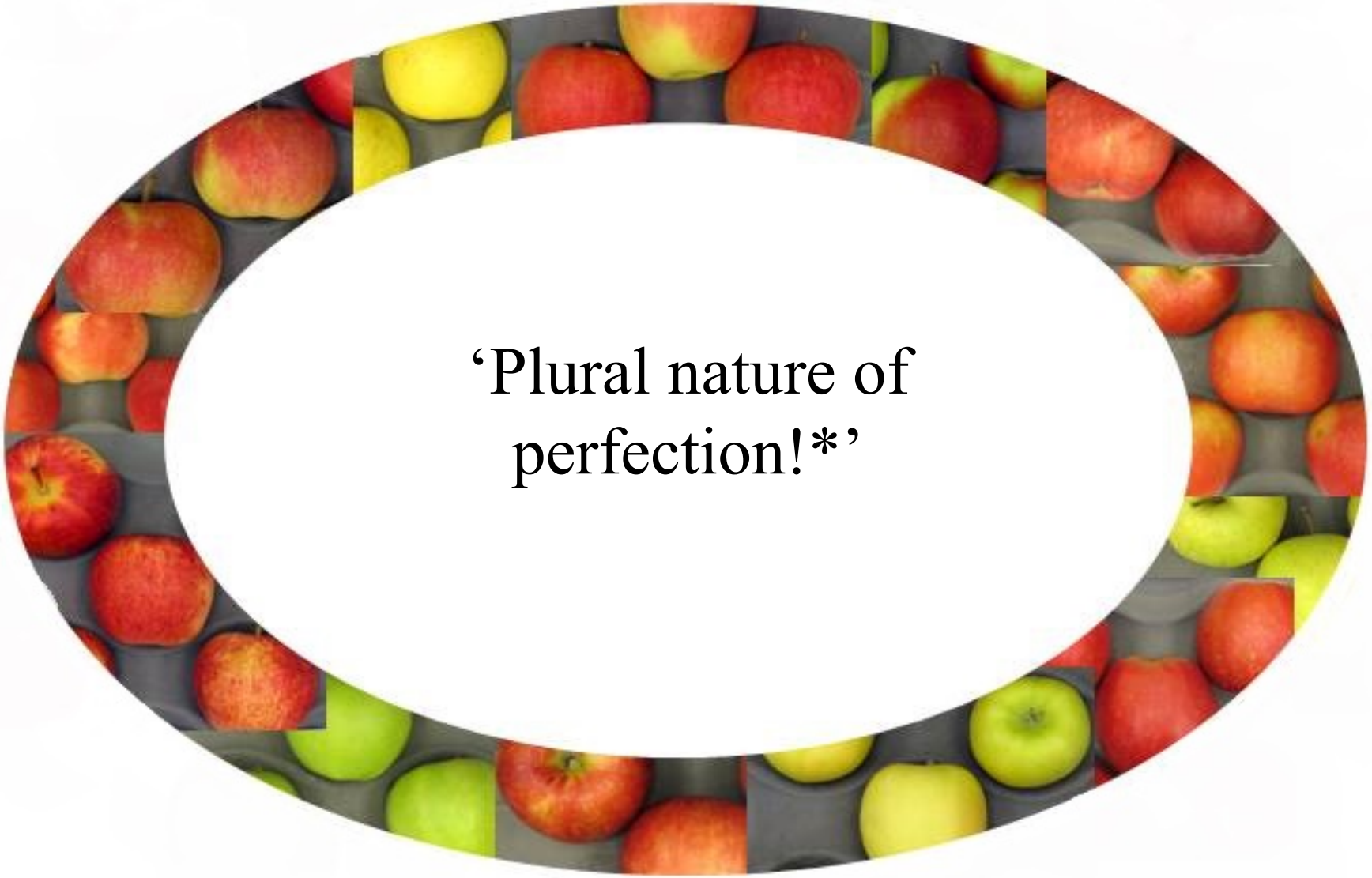
Stemilt
World Famous Fruit

WASHINGTON
TREE FRUIT
RESEARCH
COMMISSION

Commercial packing line tests

WASHINGTON TREE FRUIT RESEARCH COMMISSION

More consumer tests!



*Howard Moskowitz

Team - acknowledgements

WSU-TFREC
Bruce Barritt
Bonnie Konishi
Lisa Brutcher
Nancy Buchanan
Julia Harshman

WTFRC
Ines Hanrahan
Tom Auvil

WSU-Pullman
Cameron Peace
Daniel Edge-Garza
Terence Rowland
Carolyn Ross
Dorrie Main

National Association of Plant Breeders
NAPB
Improving Plants to Improve Lives

PLANT BREEDING & GENOMICS

extension

Thanks for joining us today.

Join us for the rest of the webinar series:
http://www.extension.org/plant_breeding_genomics

http://www.extension.org/pages/60426/webinar-registration-and-archive

Help us improve the series by taking part in the survey!