

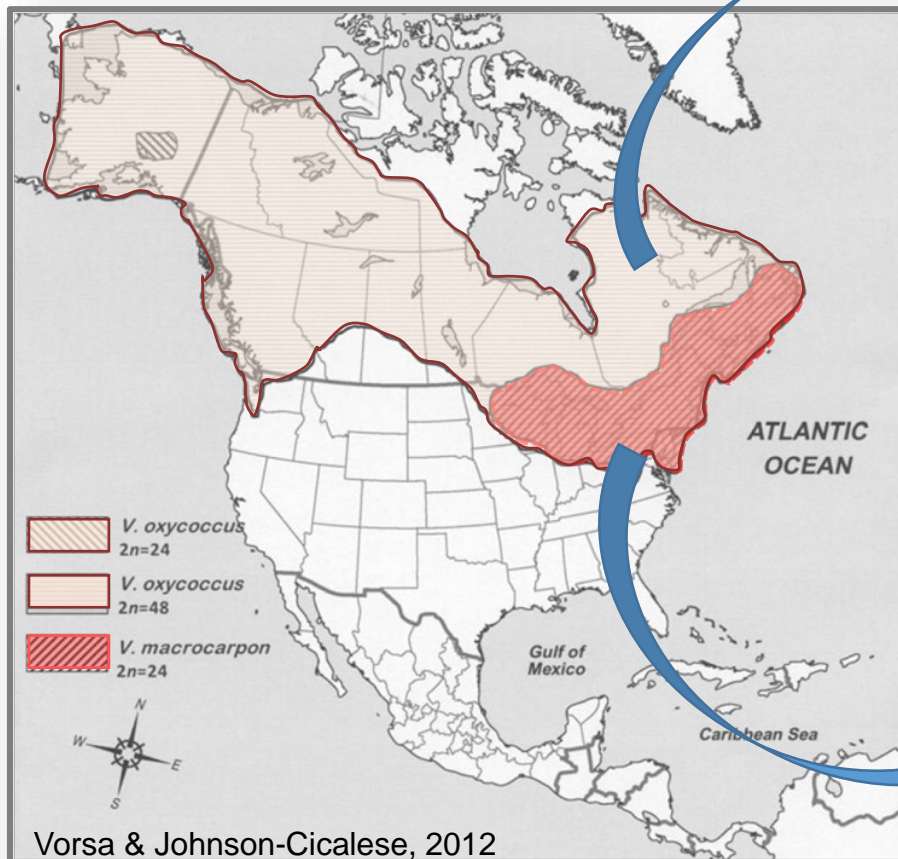
Cranberry genetic and trait research: past, present and future

Juan Zalapa
British Columbia
02/18/2020

Outline

- Domestication and breeding history
- Genetic research
- Trait research
- Breeding efforts

Domestication

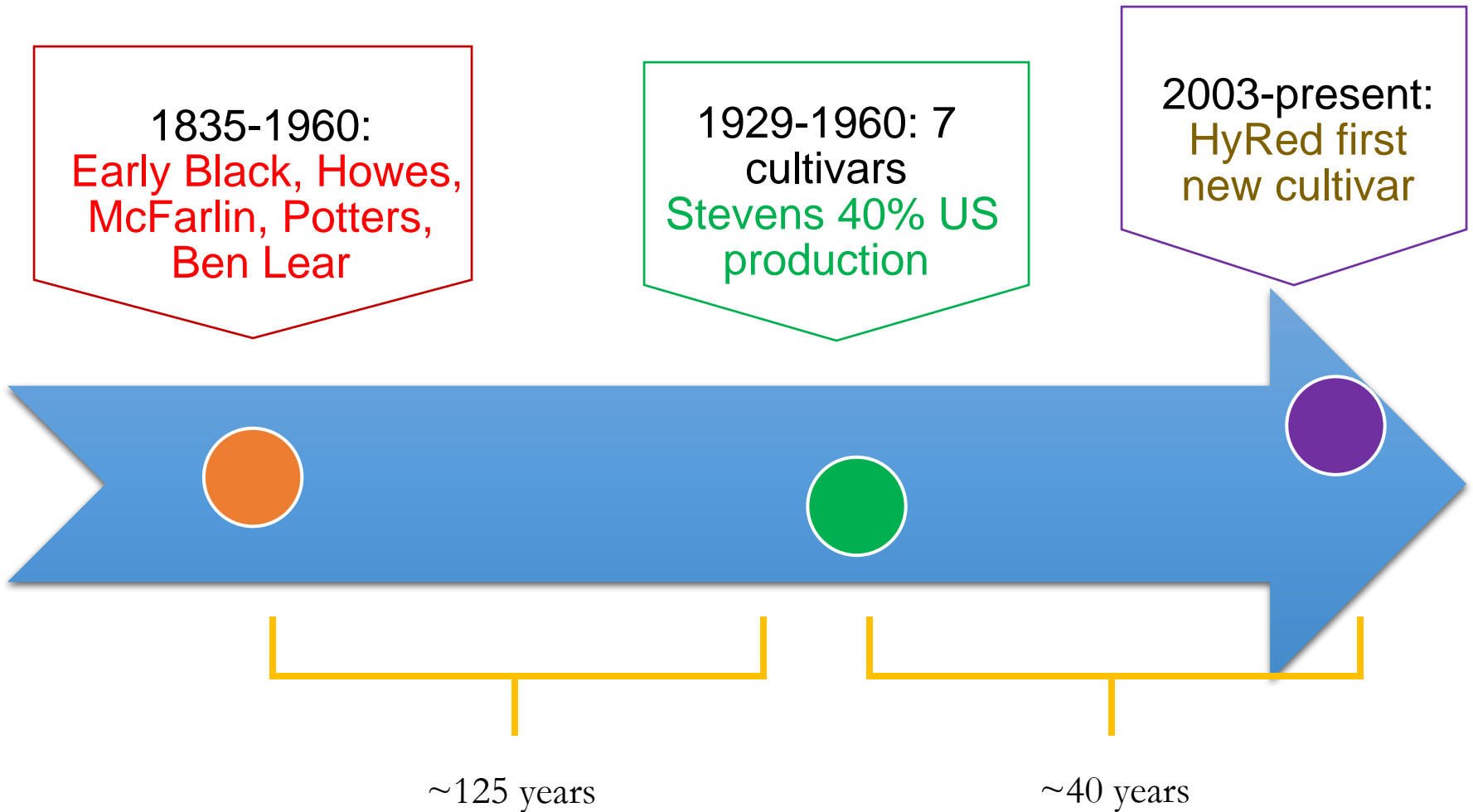


V. oxycoccus → 'sour berry'

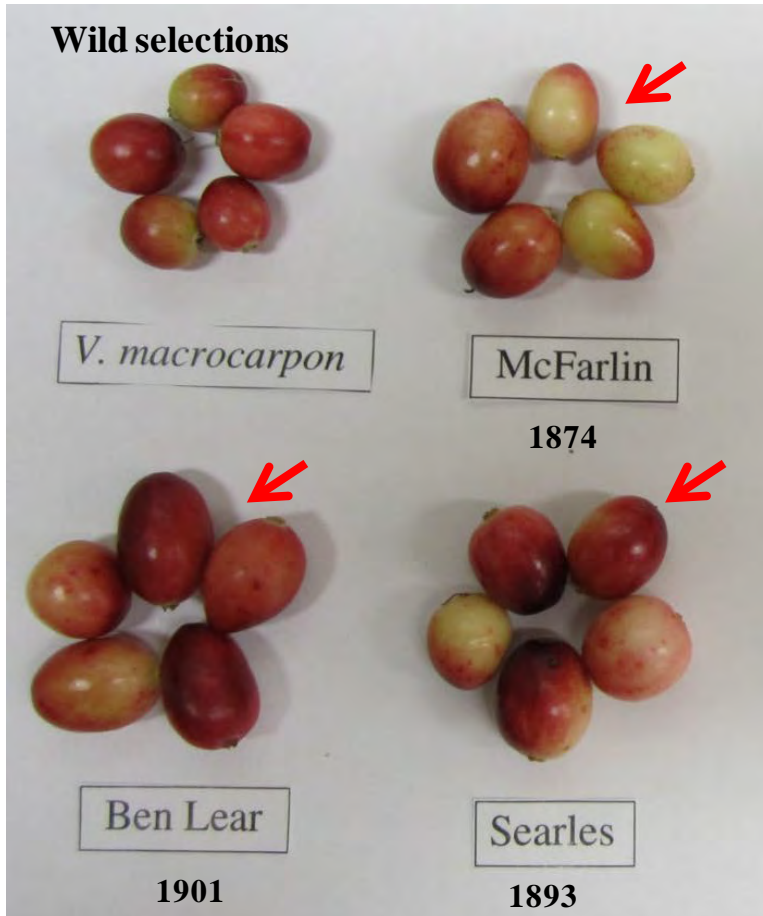


V. macrocarpon → American cranberry

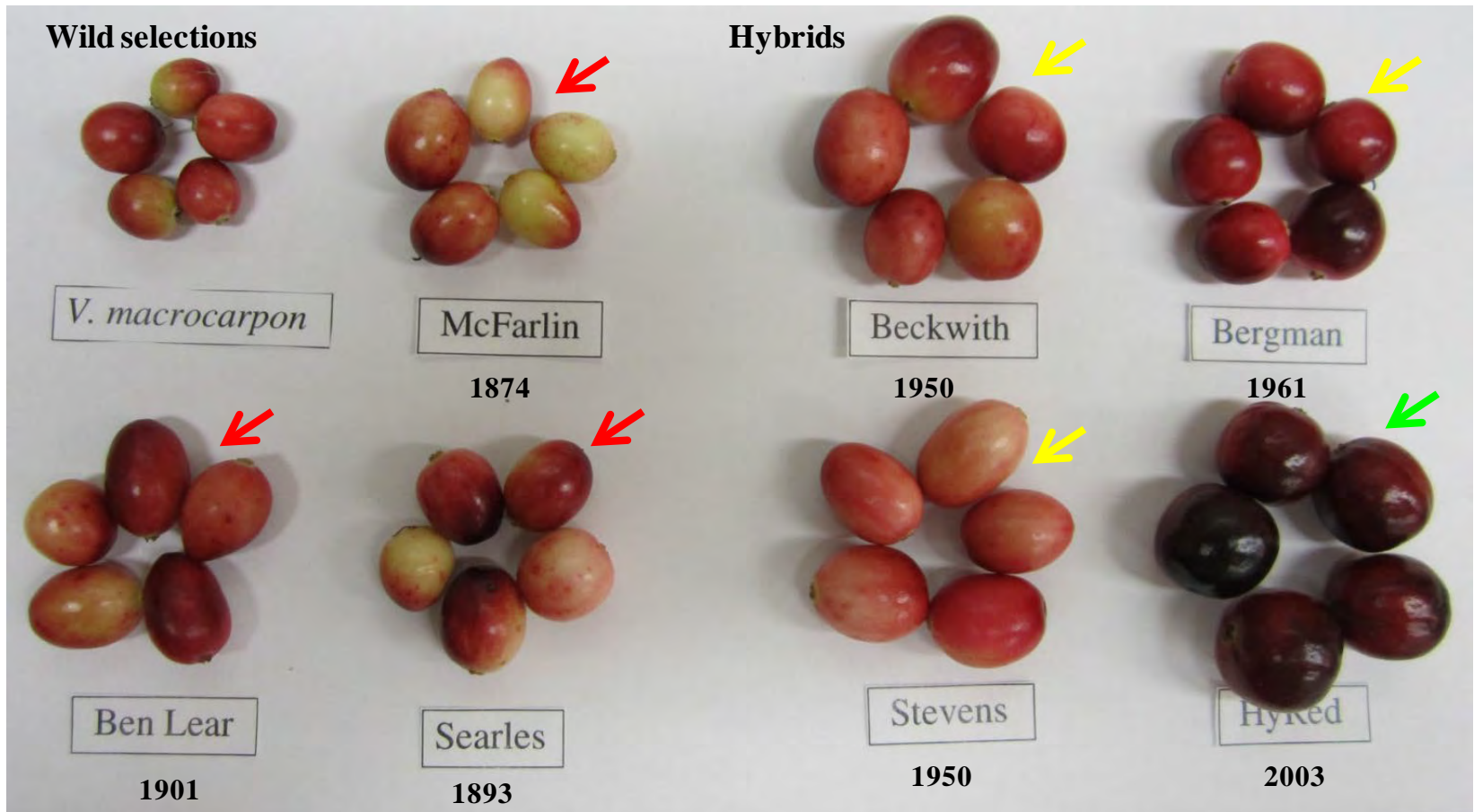
Cranberry breeding timeline



Cranberry domestication



Cranberry breeding



Why breed cranberries?

- Improved color
- Earlier berry maturing
- High yield/Rebudding (*biennial bearing*)
- *Disease/pest resistance*
- Taste
- Fruit quality and nutrition
- Cold tolerance

Breeders: USDA, UW, Rutgers, Valley Corp.



Rutgers

- Rutgers: Crimson Queen, Demoranville, Mullica Queen, Scarlet Knight, Haines, Welker.



Valley Corporation

- Valley Corporation: GH1, BG, Pilgrim King, Valley King, Midnight8, Midnight9, Crimson King, and Granite Red.
- <https://www.cranberryvine.com/cranberry-varieties>



UW-Madison

HyRed, Sundance, and Ruby Star



UW-Madison Cultivar Release 'HyRed'

- 'Stevens' x 'Ben Lear #8' (BL8 = open pollinated 'Ben Lear')
- Problem: 'Stevens' is late-maturing and in WI color development is unreliable
- Goal: Combine reliable production of 'Stevens' with good color of 'Ben Lear'
- Primary selection: **Early and uniform fruit color**

'HyRed' vs. 'Stevens' Fruit



UW-Madison Cultivar Release 'Sundance'

- 'Stevens' x 'BL8'
- Problem: 'Stevens' has unreliable fruit color in WI and is sensitive everywhere to high nitrogen fertilization
- Goal: Elevate yield without excess overgrowth and insure good fruit color development
- Primary selection: Large berry size



'Sundance'

'Stevens'

UW-Madison Cultivar Release 'Ruby Star'

- 'HyRed' x 'Bergman'
- Problem: Fill a niche earlier than 'HyRed' while also avoiding "Ben Lear' type problems"
- Goal: Combine good color of 'HyRed' with good color from an 'Early Black' derivative
- Primary selection: **Very early and uniform fruit color**

'Ruby Star'



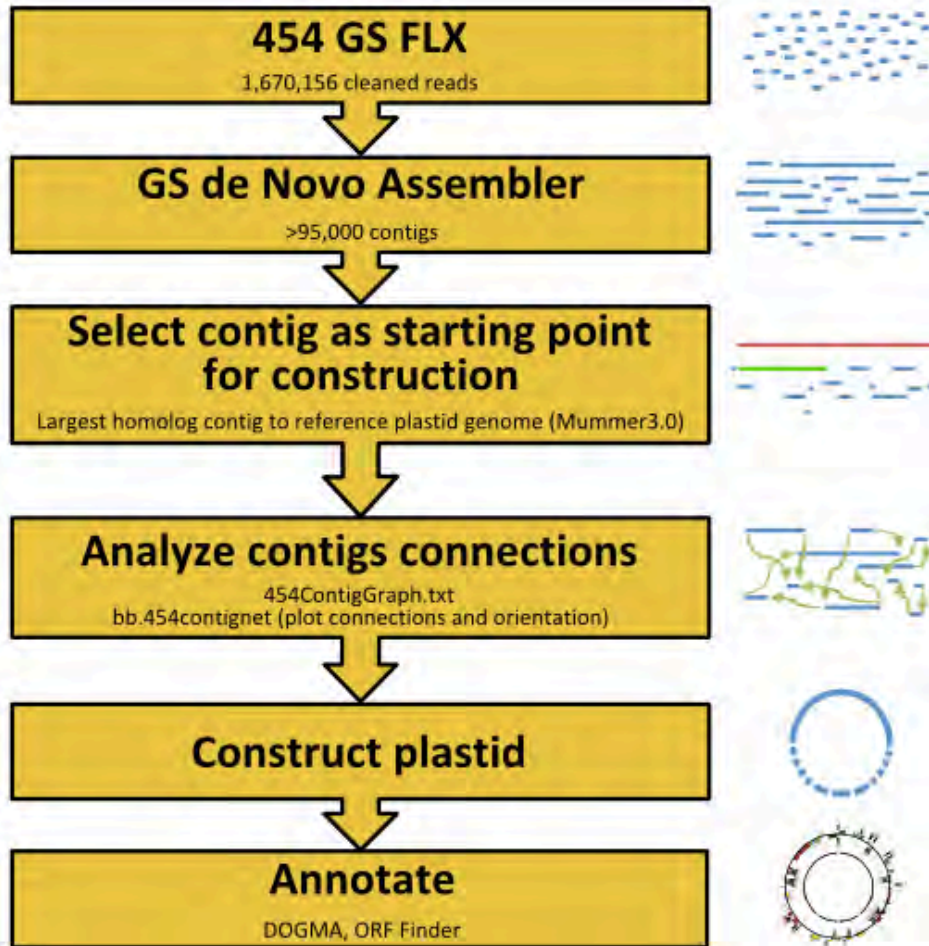
'HyRed'



'Stevens'



Molecular resources



Roche/454



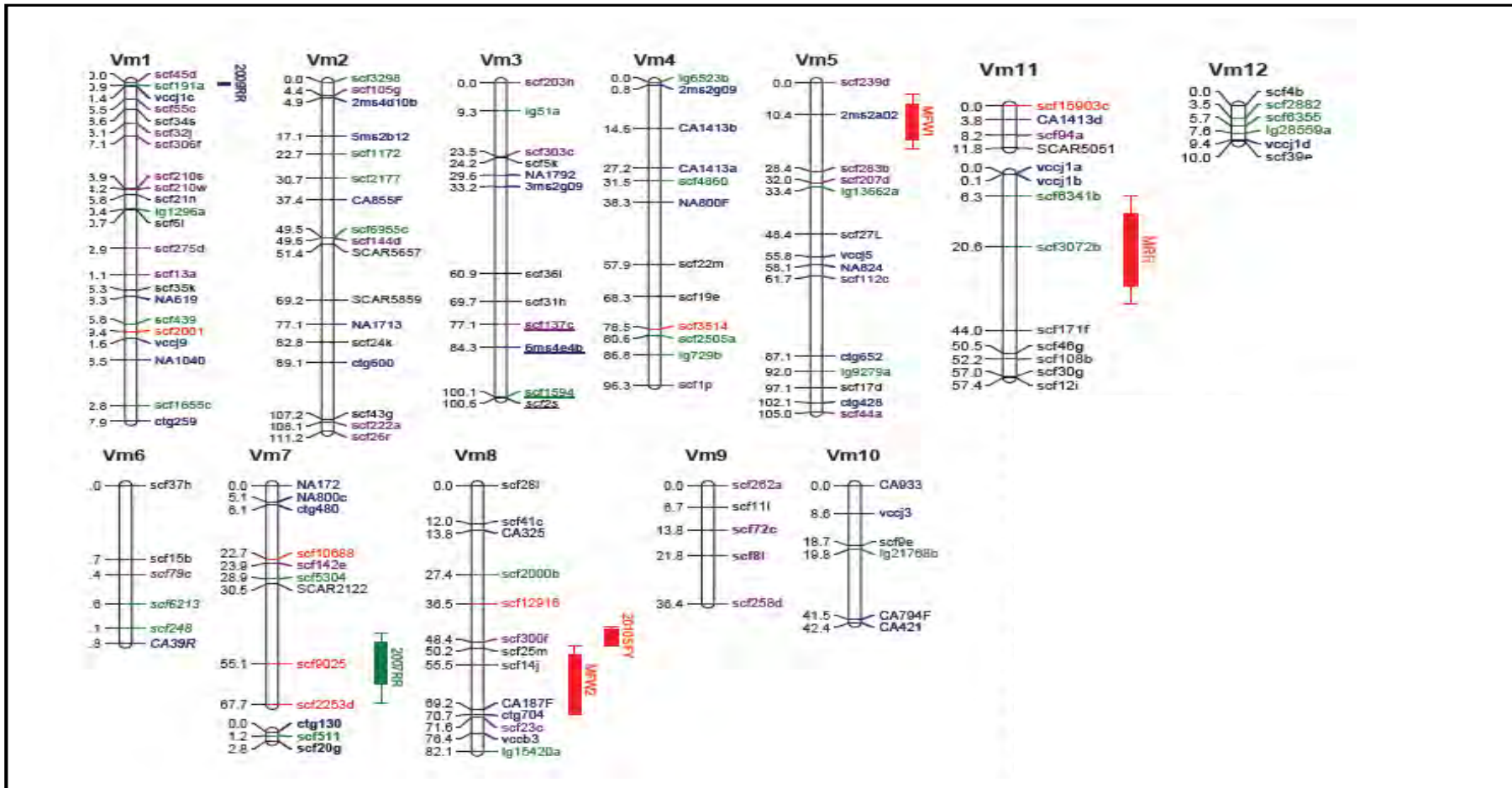
HiSeq 2000
600 Gb per run, breakthrough user experience, unmatched cost-effectiveness

Illumina

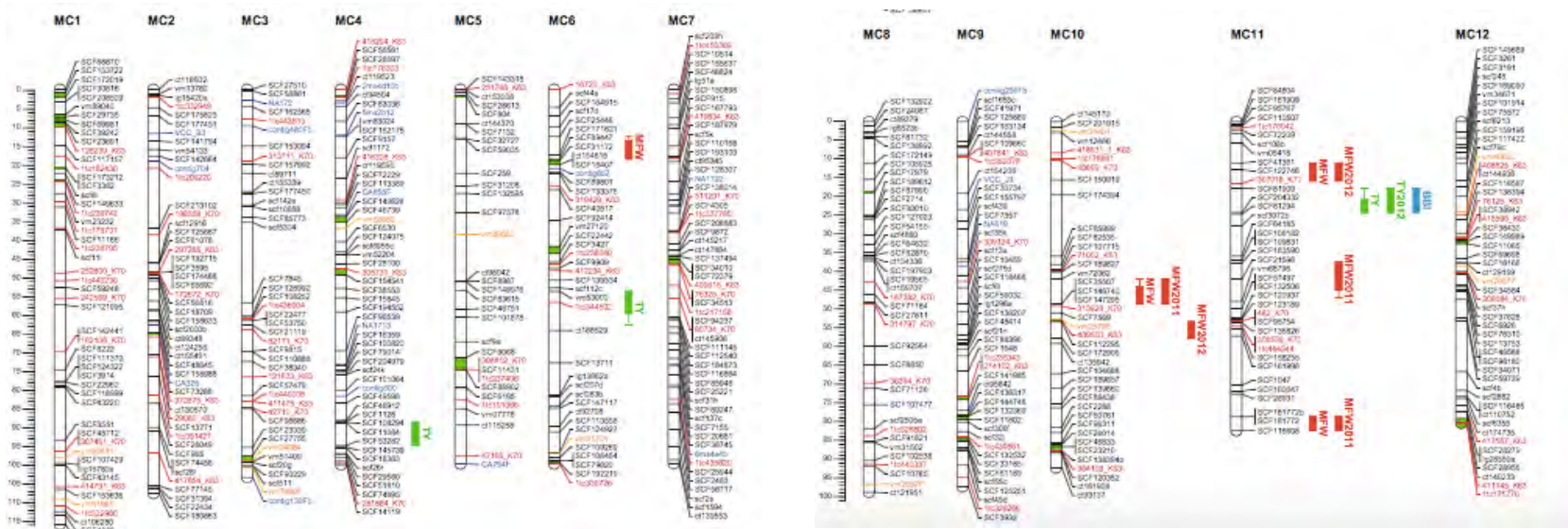


Pacific Biosciences

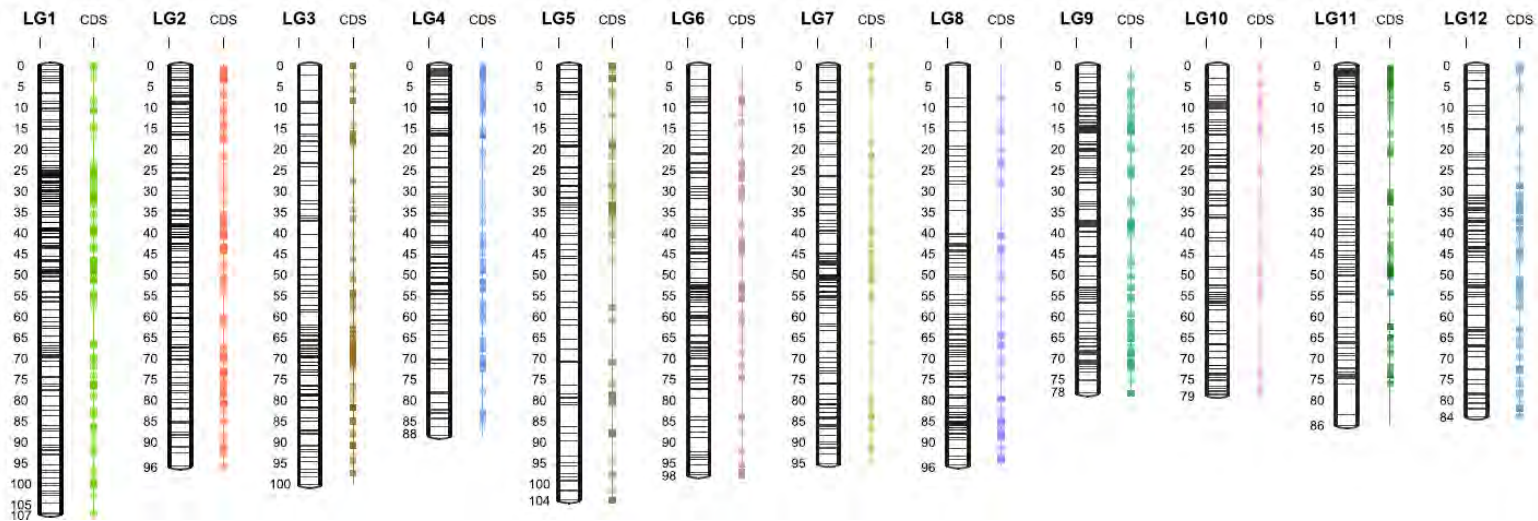
First generation map (2013): few 100 markers



Second generation map (2015): 570 markers (CNJ02)

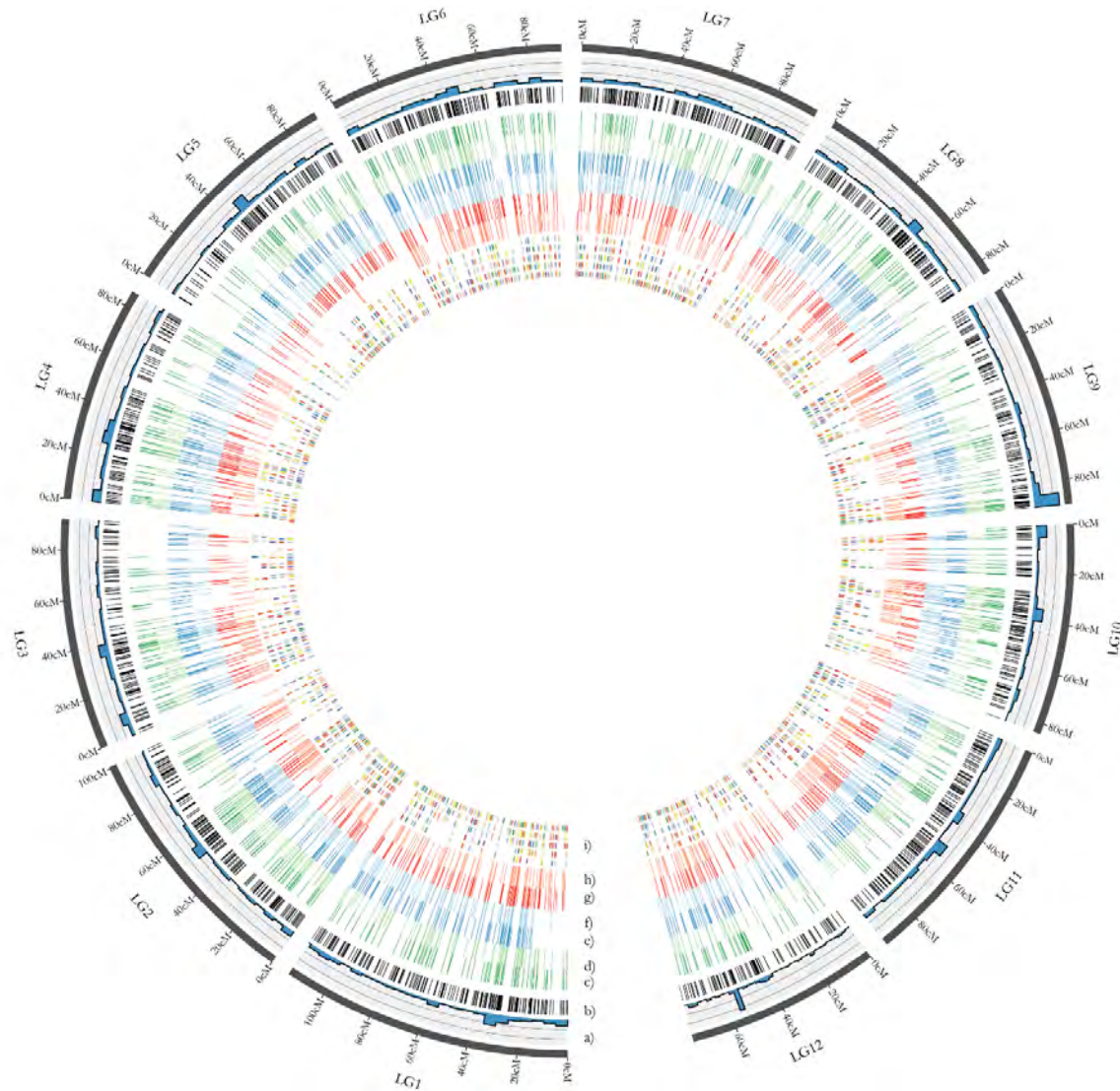


Third generation map (2016): SNP/SSR (4849) linkage map (GRYG)



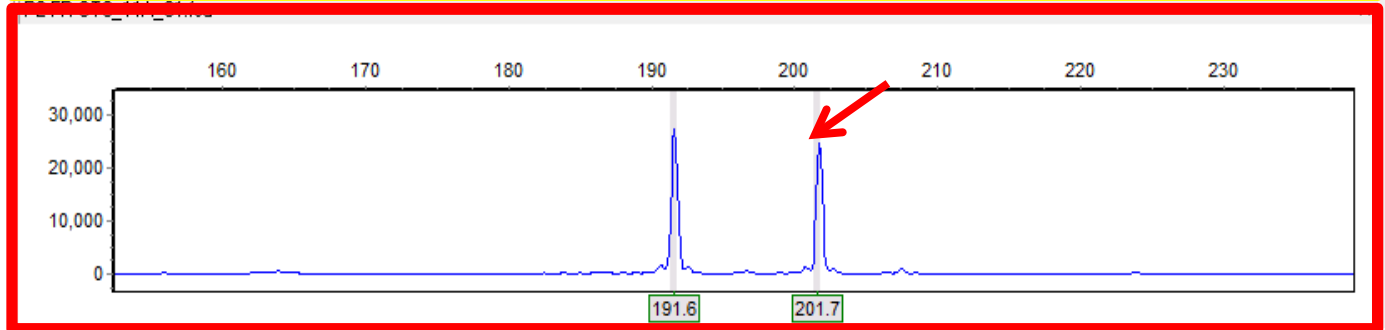
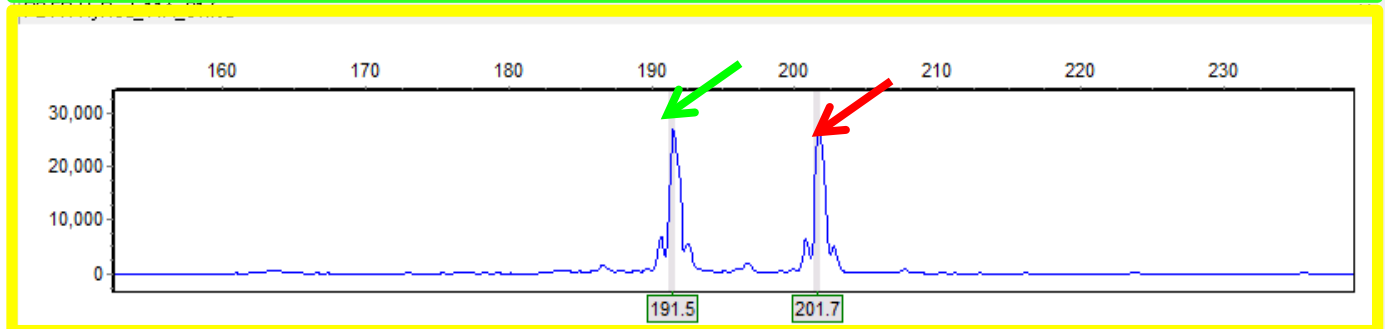
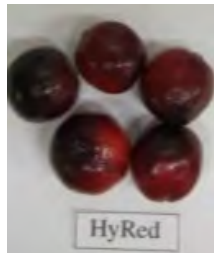
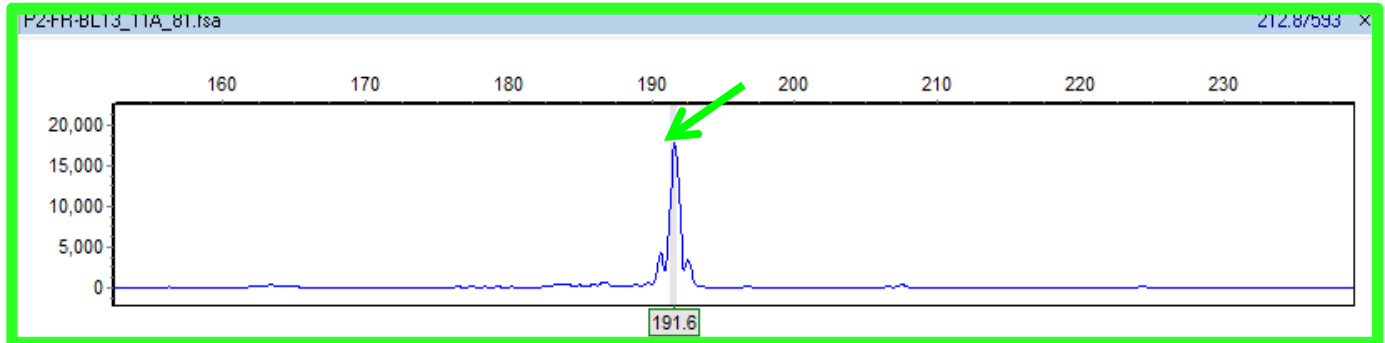
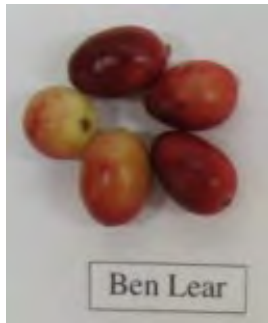
Composite Map (2017): CNJ02, CNJ04, and GRYG, 6073 markers

(c) [BGx(BLxNL)]95,
(d) GH1x35, (e)
Mullica Queen, (f)
Crimson Queen, (g)
Mullica Queen, (h)
and Stevens
parentals

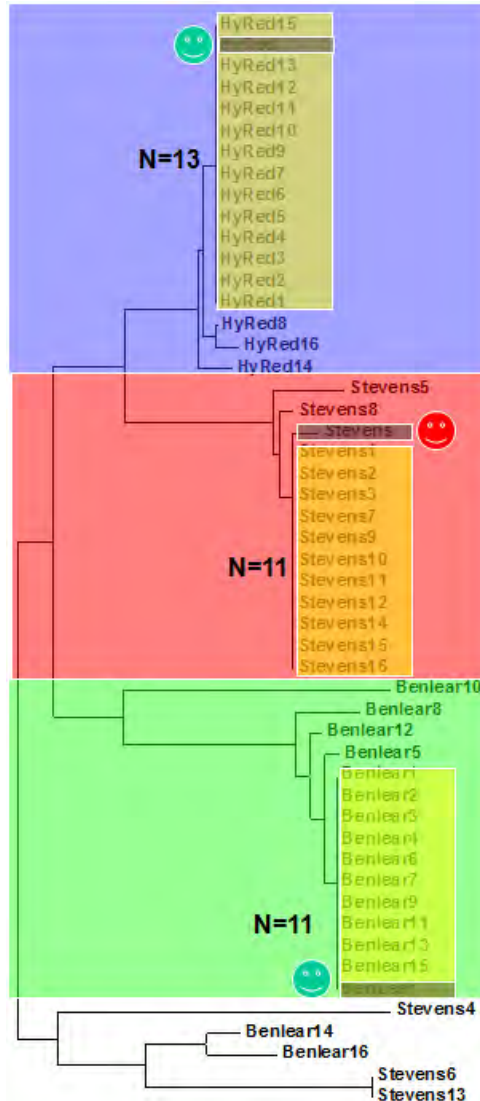


Parentage and kinship

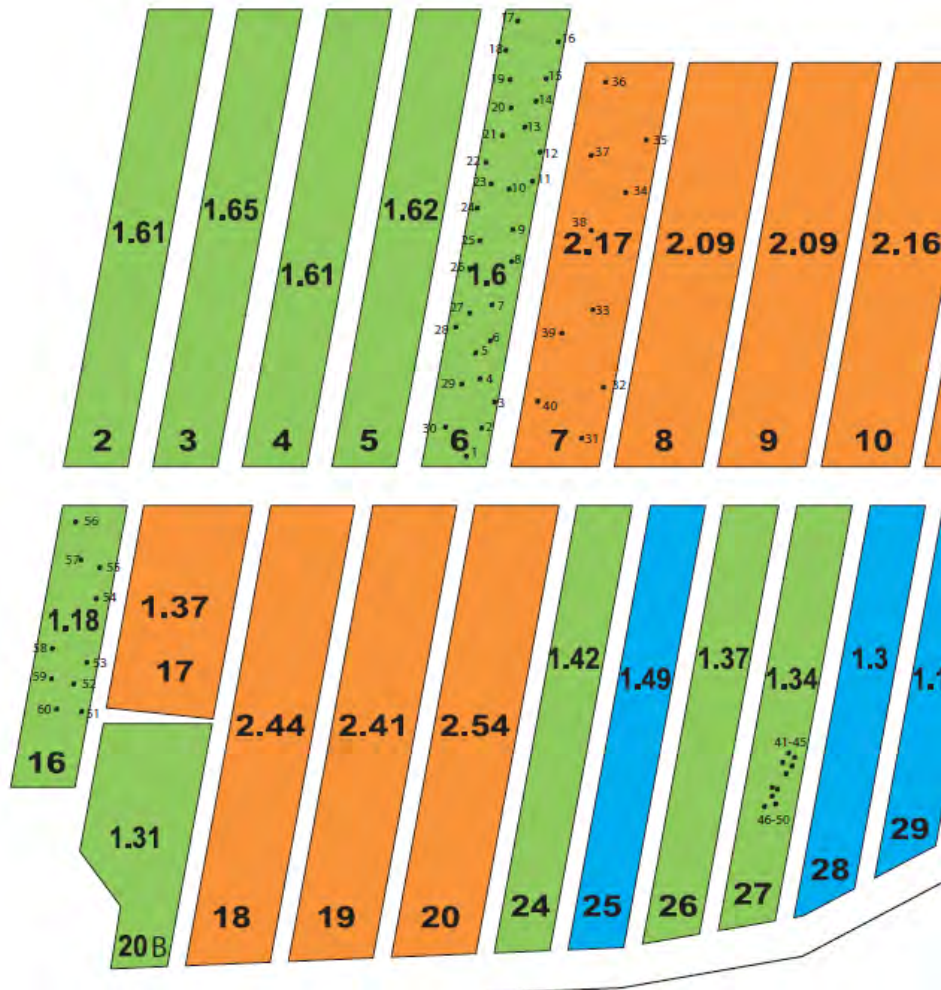
SSR-M



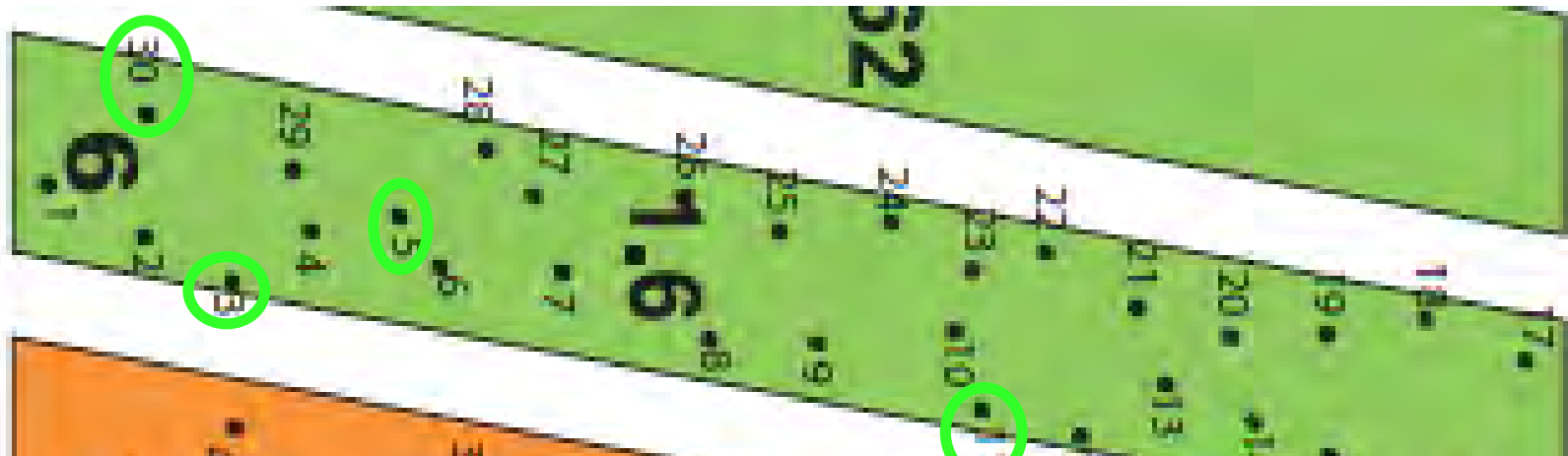
Cultivar SSR differentiation

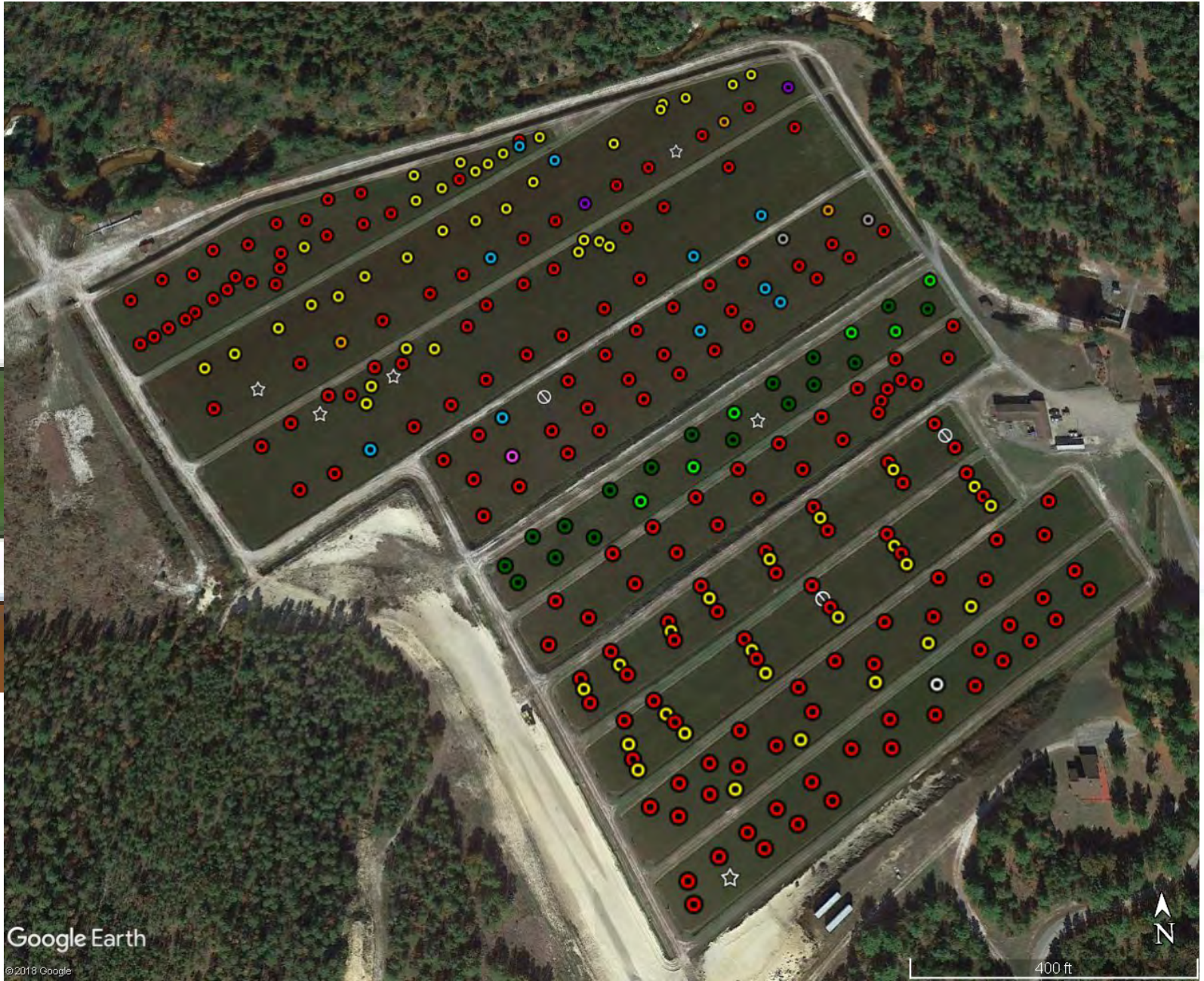


Genetic purity evaluation of cranberry beds



Genetic purity evaluation of cranberry beds





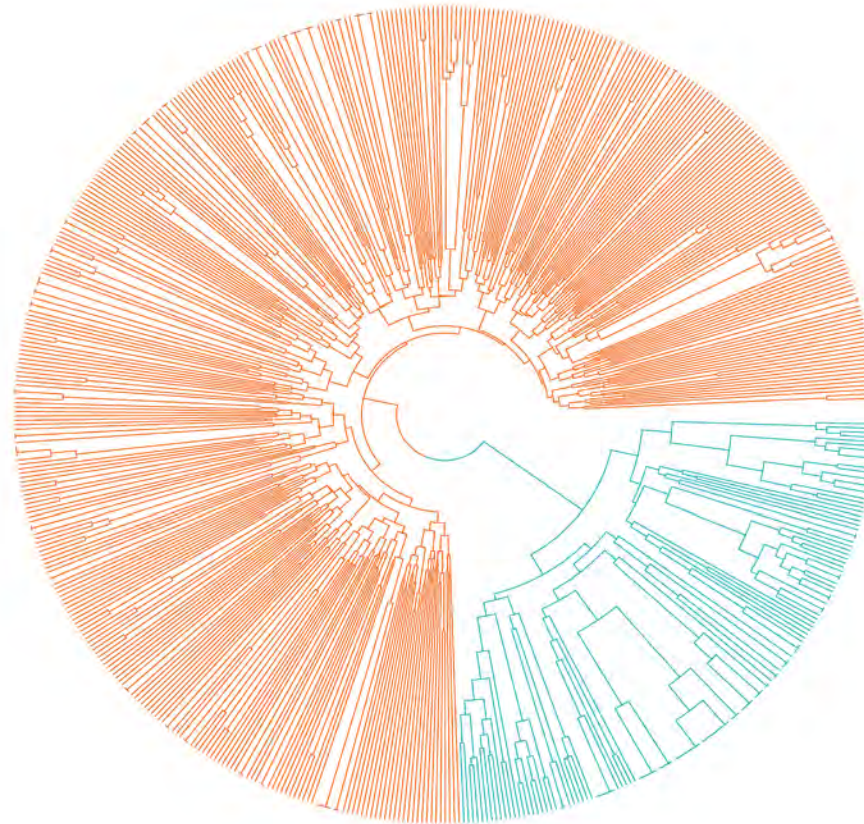
Google Earth



© 2018 Google

400 ft



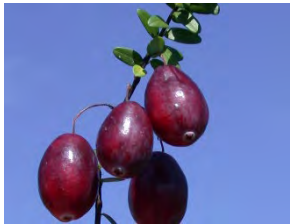
Cranberry species differentiation



 *V. oxycoccus*
 *V. macrocarpon*



Transferability of markers in *Vaccinium*



cranberry



lingonberry



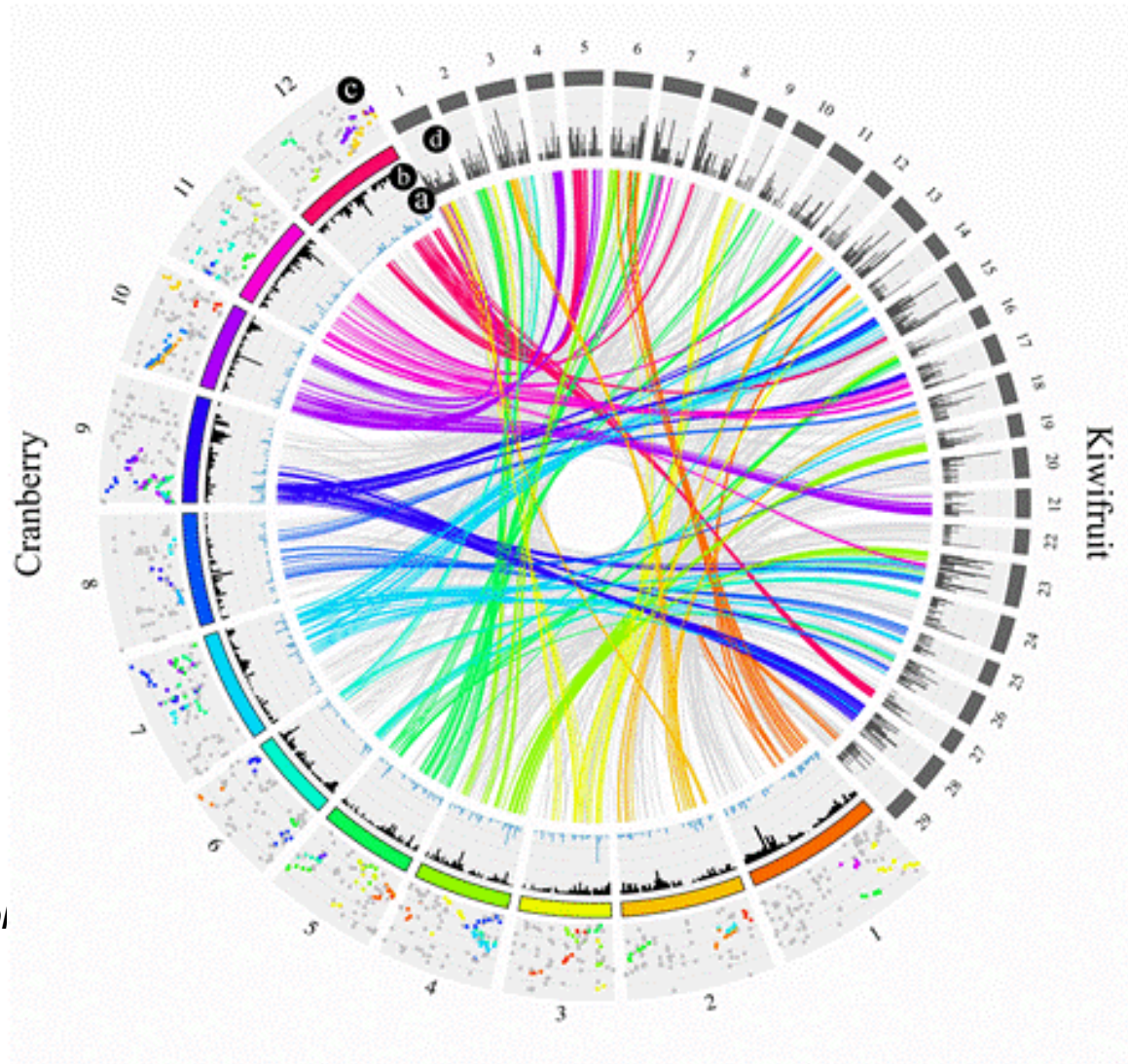
bilberry



blueberry

- *V. oxycoccus* = small cranberry (2x, 4x, 6x)
- *V. vitis-idaea* = lingonberry (2x)
- *V. corymbosum* = Northern and Southern high bush blueberry (2x, 4x, 6x)
- *V. darrowii* = Gave rise to Southern high bush (2x)
- *V. angustifolium* = Canada, low bush blueberry (2x, 4x)
- *V. myrtillus* = Europe, bilberry (2x)

Cranberry and blueberry linkage mapping



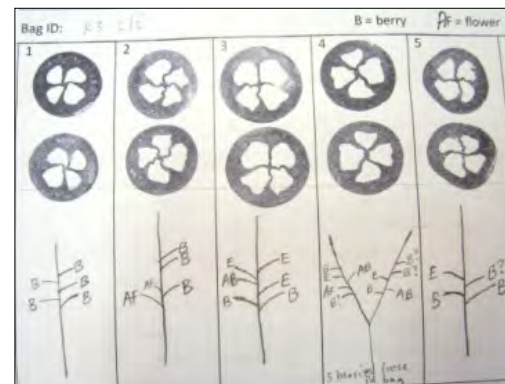
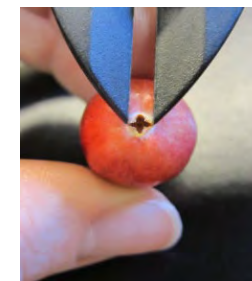
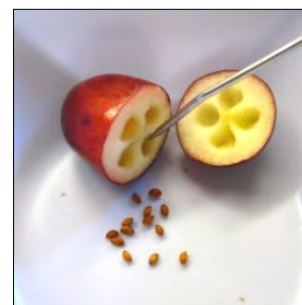
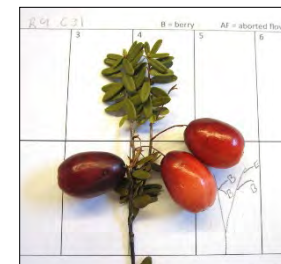
Vaccinium
oxycarpum

F1#10 x W85-23
diploid interspecific blueberry-mantle

Kiwifruit

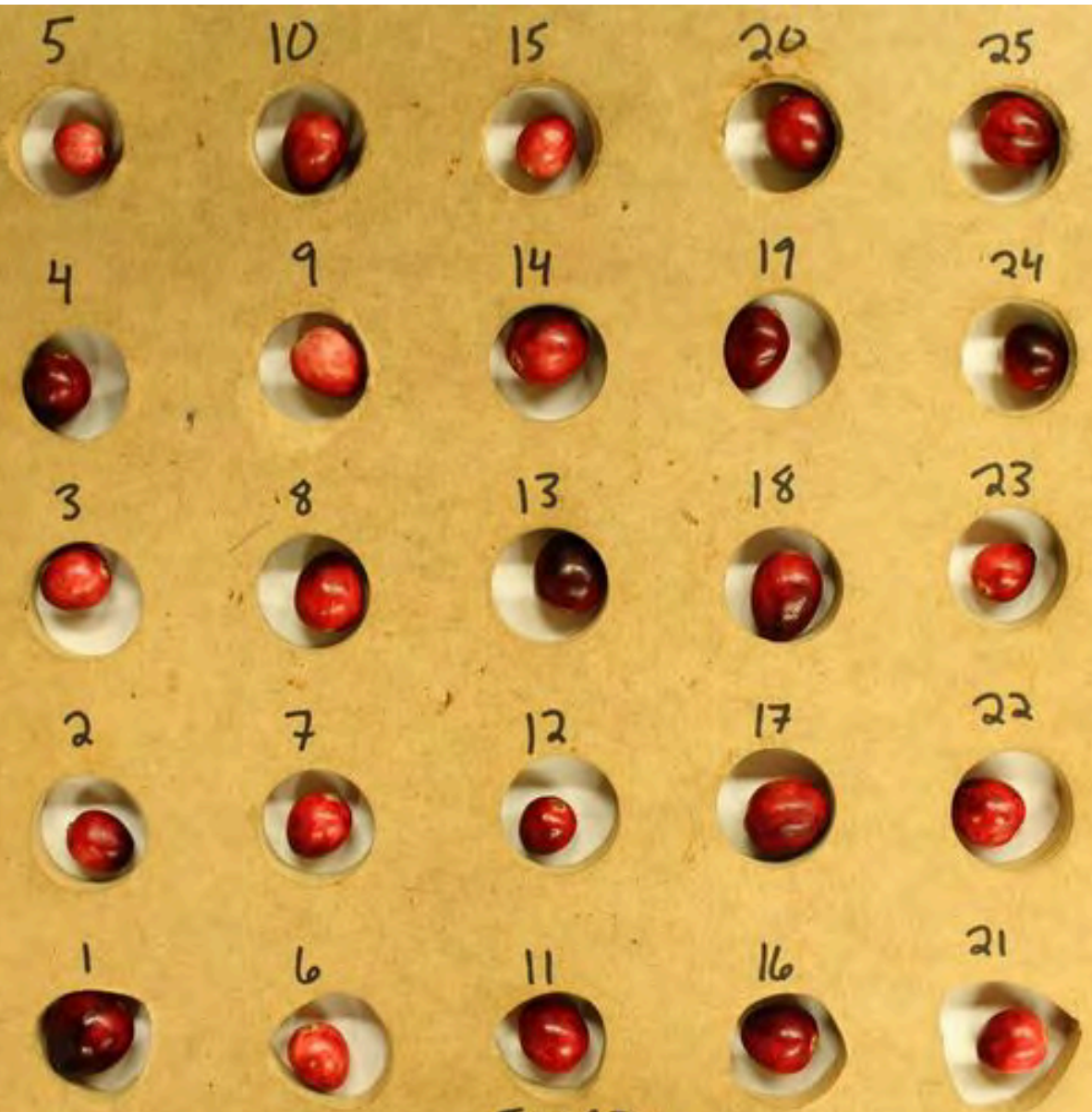
Vaccinium
macrocarpon

Traditional trait data collection

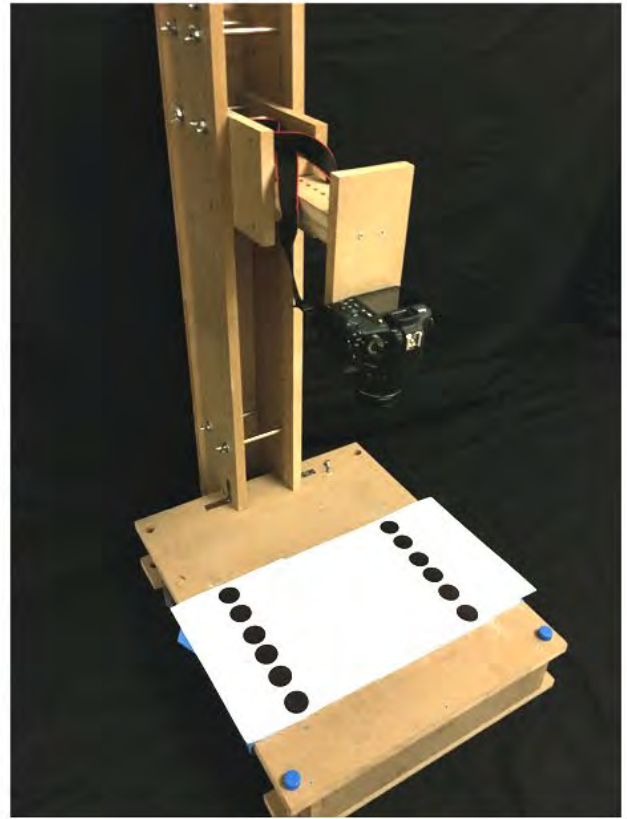
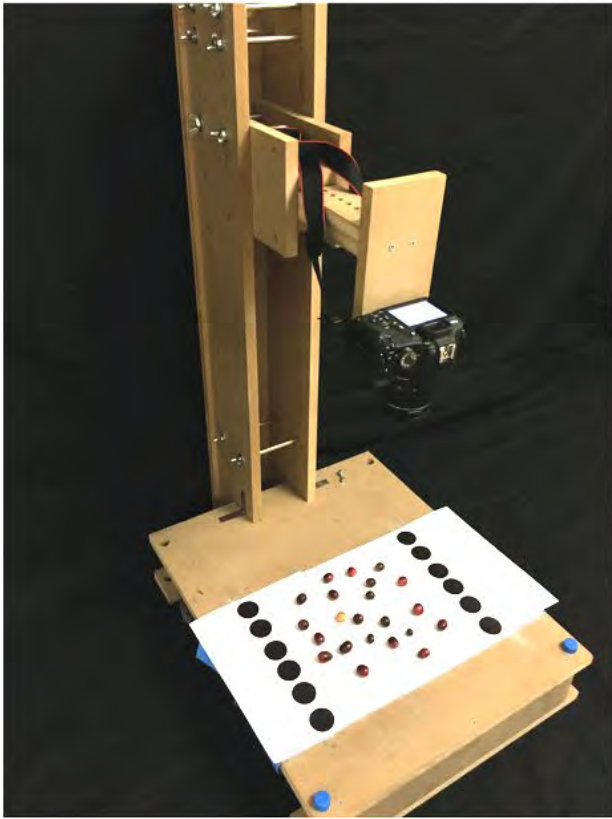


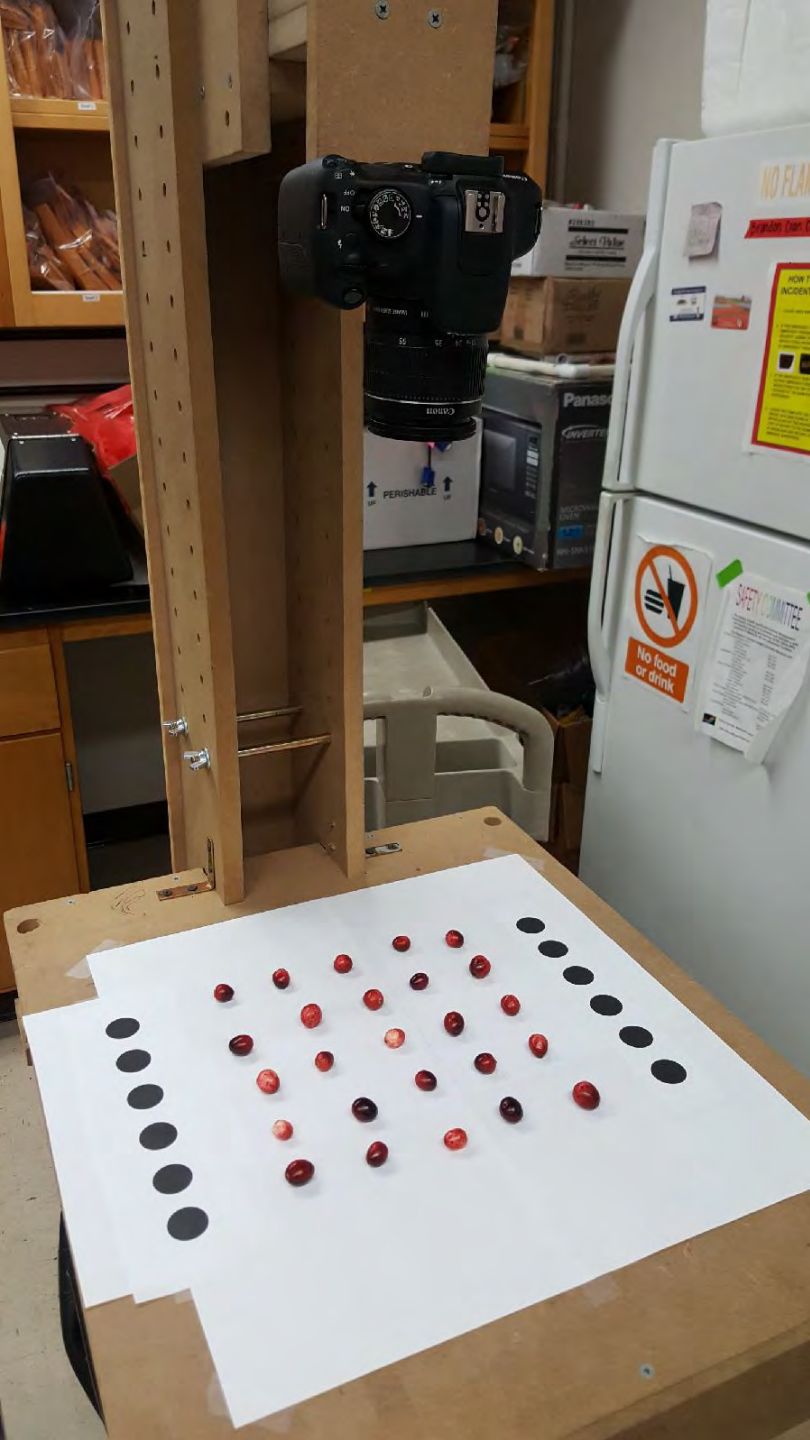
GiNA: digital trait data collection

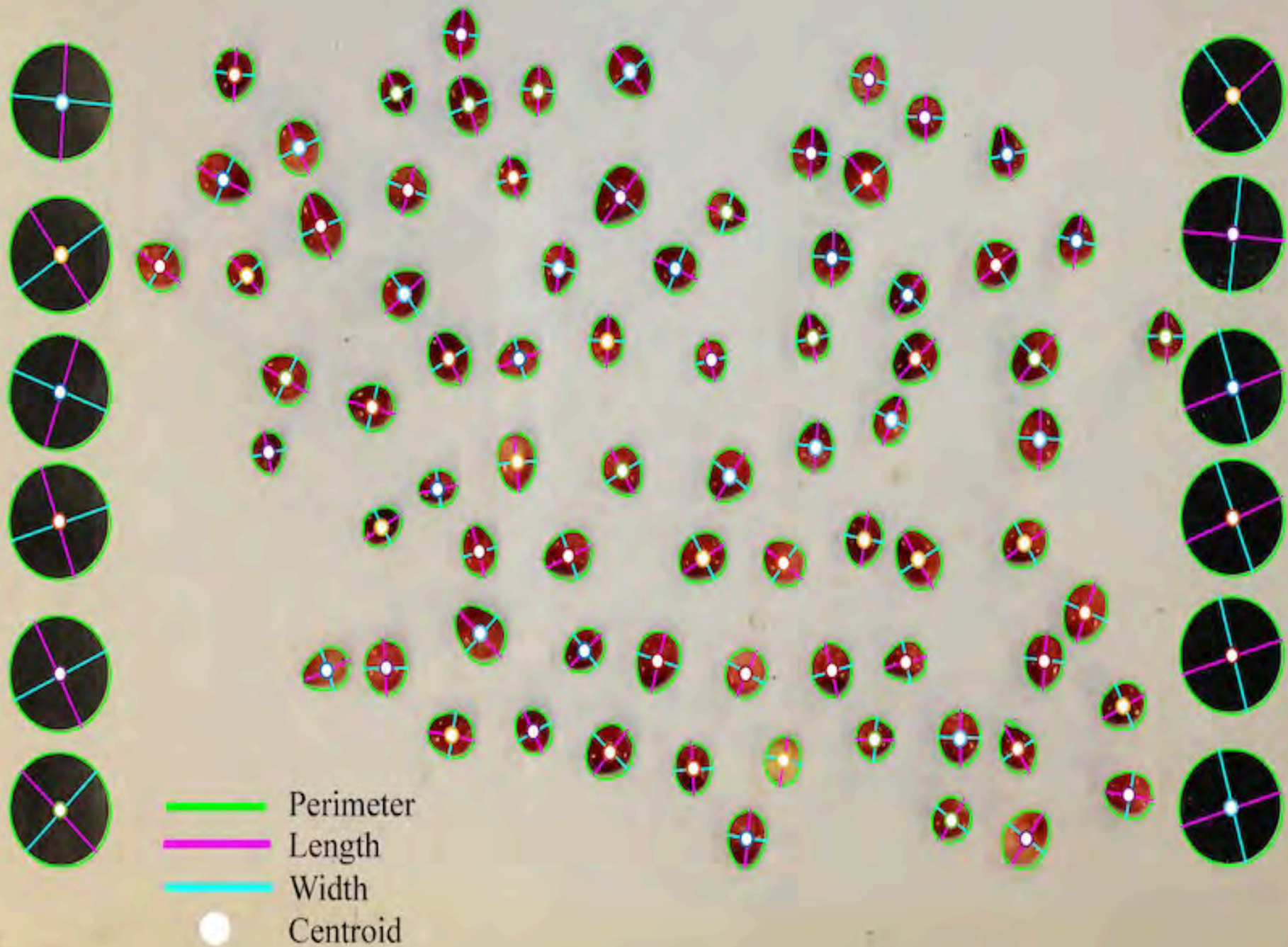




Forward Tower
|







Fruit color analysis

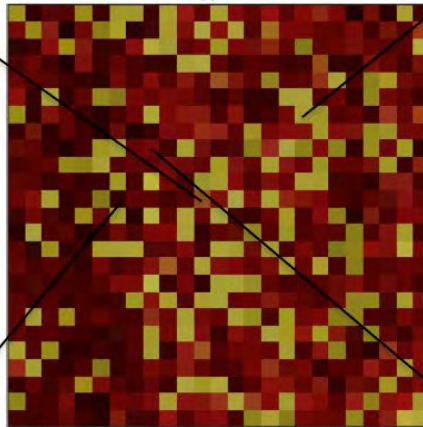
Genotype K14



Genotype 030



Genotype colors



Genotype E9



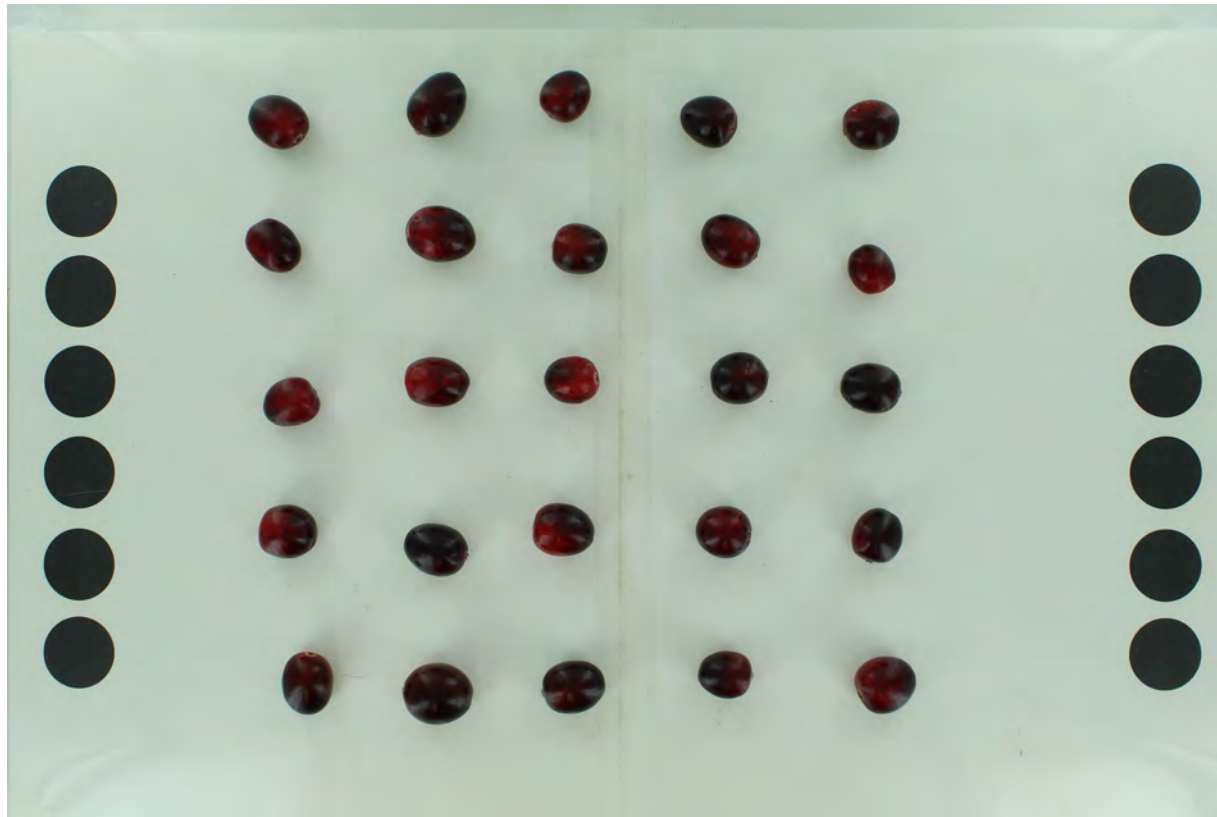
Genotype G22



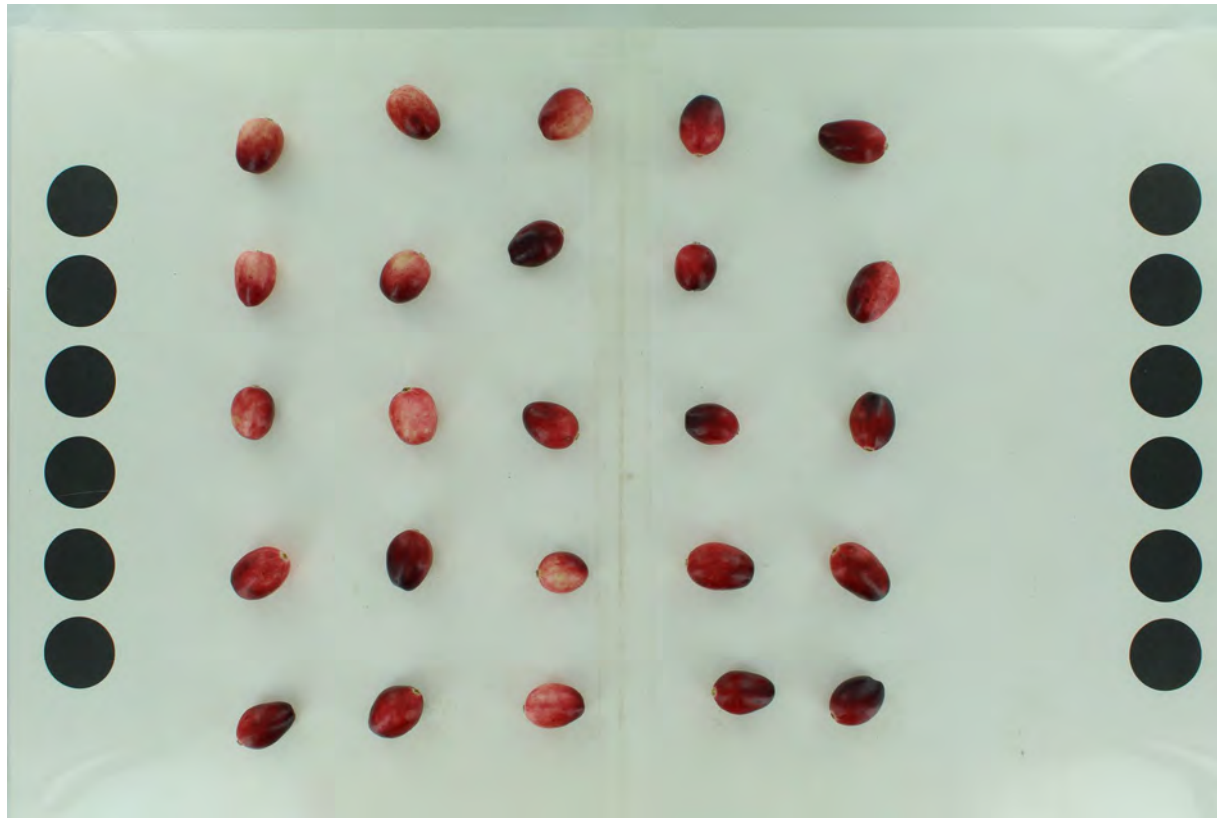
GiNA, an efficient and high-throughput software for 11 horticultural traits

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	sample	len	wid	area	per	shape	surf	vol	ecc	sol	color	colorvar	time
2	1	1.0562	0.51925	0.49067	0.25537	0.50363	0.26113	0.12525	2.3072	0.99578	0.78756	1.4007	1
3	1	1.0701	0.57294	0.53435	0.30626	0.55265	0.31538	0.1639	2.5081	0.99642	0.83714	1.3757	1
4	1	1.1081	0.59784	0.53848	0.32273	0.56814	0.3361	0.17368	2.9569	0.99432	0.79017	1.0726	1
5	1	1.1848	0.58387	0.49183	0.28724	0.53995	0.30753	0.14151	3.6058	0.99432	0.86545	1.3218	1
6	1	1.2093	0.61059	0.50395	0.30825	0.55817	0.33205	0.15536	3.767	0.99573	0.8158	1.2057	1
7	1	1.0745	0.37331	0.34675	0.12969	0.35805	0.13356	0.044971	2.5663	0.993	0.76055	1.3408	1
8	1	1.1313	0.56657	0.49984	0.28351	0.53497	0.29801	0.14182	3.1817	0.99429	0.86398	1.6155	1
9	2	1.0501	0.57555	0.55007	0.31571	0.56089	0.32124	0.17437	2.3167	0.99762	0.61532	0.81086	1
10	2	1.336	0.65852	0.49468	0.32494	0.58084	0.36187	0.16135	4.6485	0.99444	0.61399	1.3132	1
11	2	1.1458	0.64691	0.56666	0.36434	0.61043	0.38462	0.208	3.4878	0.99425	0.70623	0.95819	1
12	2	1.3202	0.73505	0.55881	0.40509	0.71482	0.45431	0.22983	4.5797	0.96319	0.64612	1.0817	1
13	2	1.1891	0.62873	0.53069	0.33288	0.58192	0.35502	0.1773	3.8363	0.99631	0.63539	0.84847	1
14	2	1.1277	0.59533	0.52984	0.31442	0.56163	0.32896	0.16734	3.3182	0.99609	0.77912	1.0189	1
15	2	1.0329	0.59544	0.57856	0.34364	0.58541	0.34732	0.19957	1.9846	0.9965	0.64993	1.0179	1
16	2	1.098	0.64529	0.58983	0.37574	0.61517	0.39291	0.22479	2.9987	0.99105	0.58856	0.4075	1
17	2	1.2552	0.67758	0.5418	0.36607	0.61041	0.39858	0.19915	4.2563	0.99696	0.6046	1.3964	1
18	2	1.2625	0.66207	0.5263	0.34744	0.59587	0.37914	0.18362	4.2969	0.99611	0.81598	1.3392	1
19	2	1.1139	0.60151	0.54195	0.32304	0.57206	0.33838	0.1769	3.1774	0.99077	0.70417	0.88683	1
20	2	1.3684	0.67277	0.49343	0.33118	0.58653	0.37197	0.16401	4.7786	0.99465	0.43897	0.14158	1
21	2	1.2033	0.70255	0.58597	0.41028	0.64675	0.44002	0.24155	3.937	0.99559	0.73016	1.1732	1
22	2	1.3413	0.60163	0.45019	0.26987	0.53423	0.3013	0.12209	4.6704	0.99073	0.64257	0.67183	1
23	2	1.1461	0.66888	0.58575	0.39074	0.62834	0.41112	0.22979	3.4906	0.99569	0.60144	0.65306	1
24	2	1.1977	0.59608	0.49949	0.29705	0.54946	0.31766	0.14891	3.8981	0.99352	0.61658	0.81542	1
25	2	1.1969	0.57193	0.47957	0.27343	0.52471	0.29257	0.1317	3.8926	0.99628	0.67547	0.98136	1
26	2	1.0899	0.62606	0.5765	0.35986	0.60427	0.37153	0.20834	2.9007	0.99356	0.51745	0.8191	1
27	2	1.1617	0.60185	0.51998	0.31123	0.57681	0.33007	0.16294	3.6243	0.97887	0.63663	1.281	1
28	2	1.1319	0.62877	0.55753	0.34968	0.59313	0.3661	0.19569	3.3592	0.99541	0.66013	1.0589	1
29	2	1.1731	0.5941	0.50826	0.3002	0.56131	0.31967	0.15367	3.7164	0.9878	0.60874	1.1696	1
30	2	1.3073	0.59621	0.45771	0.27211	0.52758	0.30076	0.12507	4.5213	0.99537	0.82506	1.1805	1
31	2	1.0963	0.63043	0.57712	0.36288	0.60403	0.37537	0.21025	2.9789	0.99614	0.47853	0.36973	1

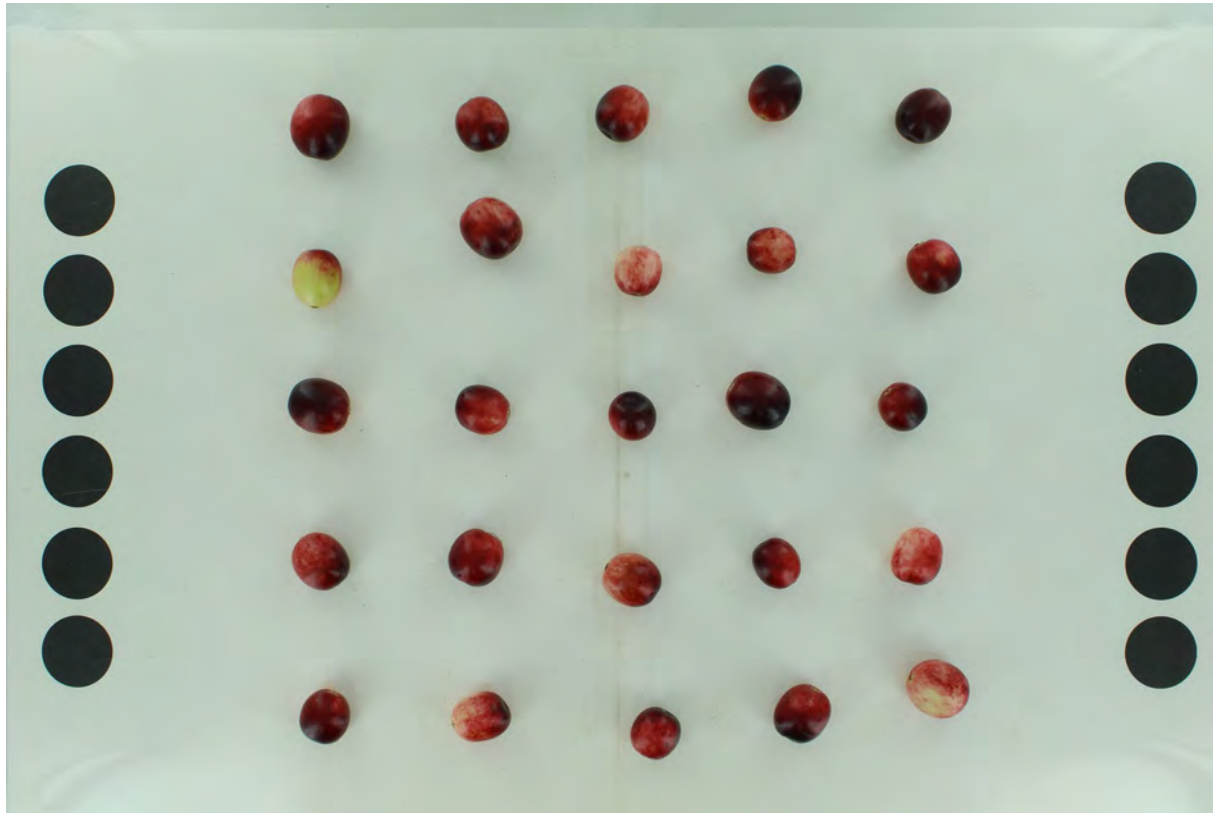
Crimson King



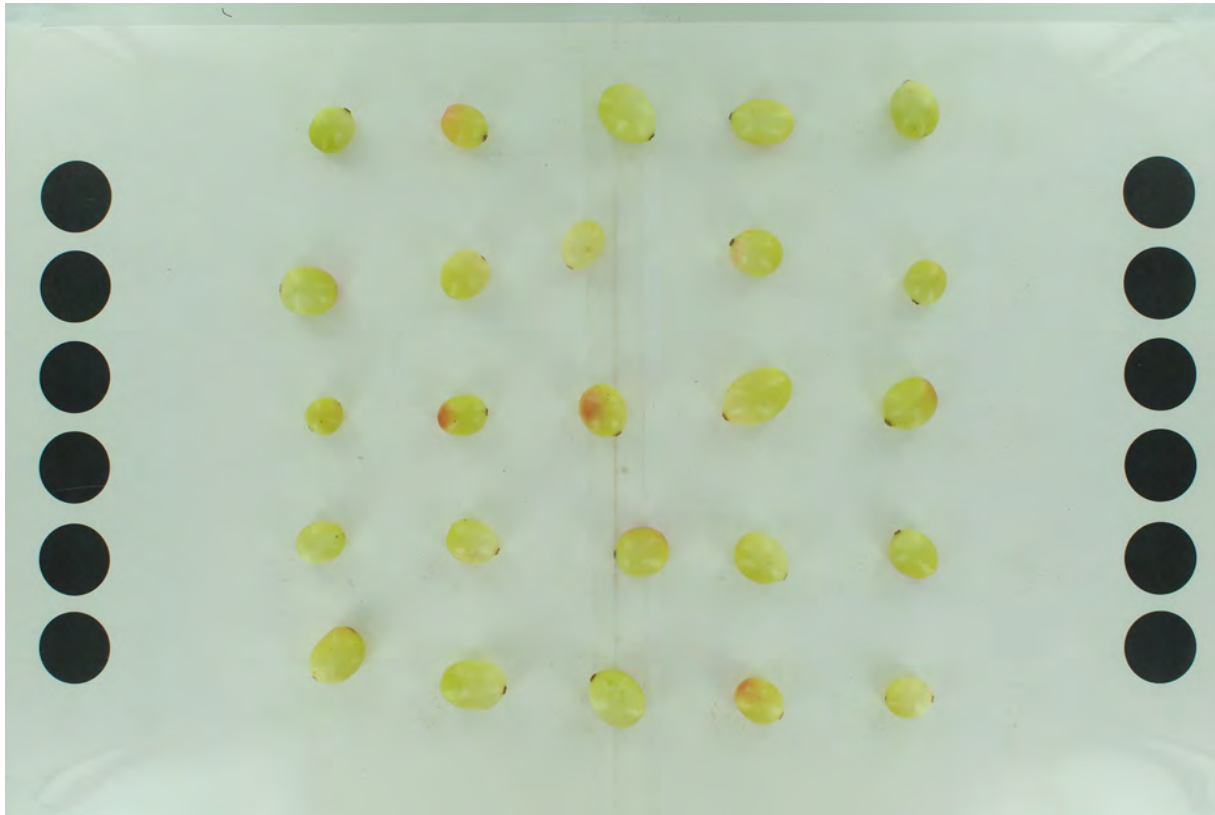
Midnight 9



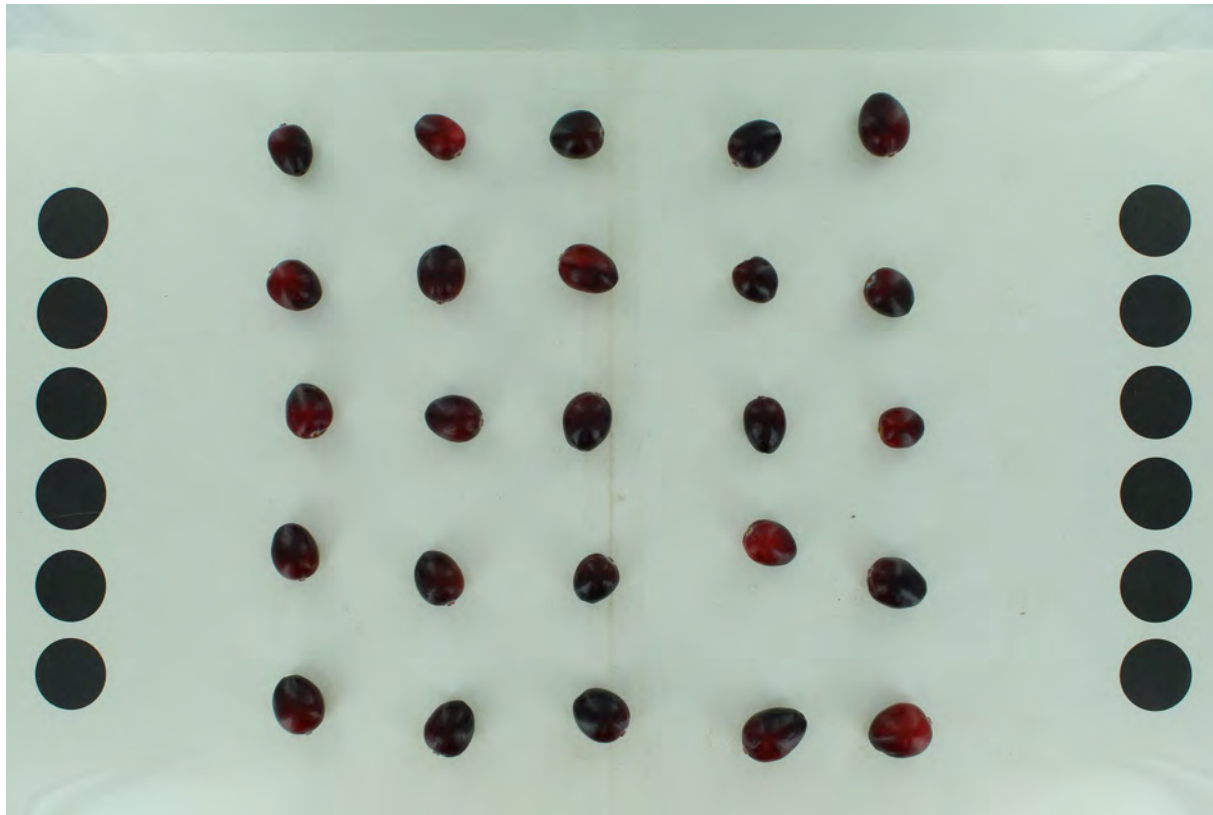
Valley King



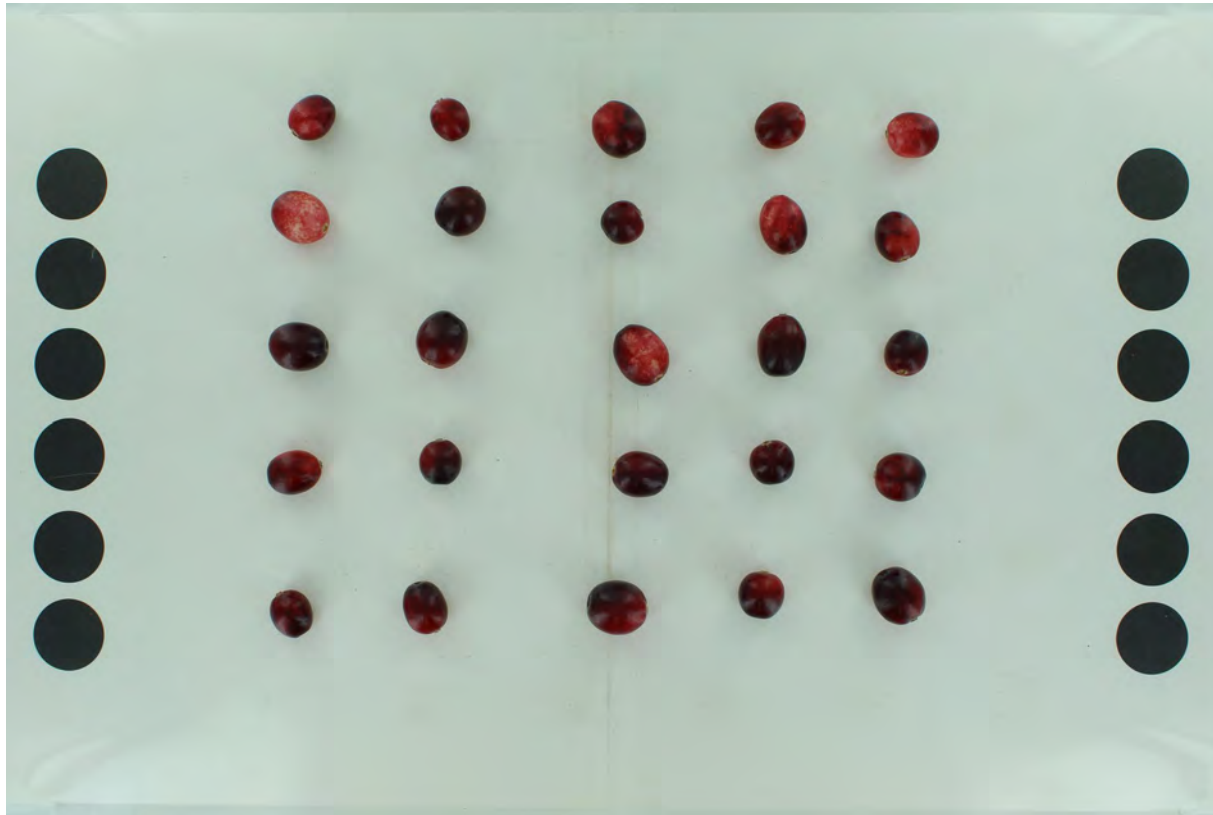
Yellow Bell hybrid



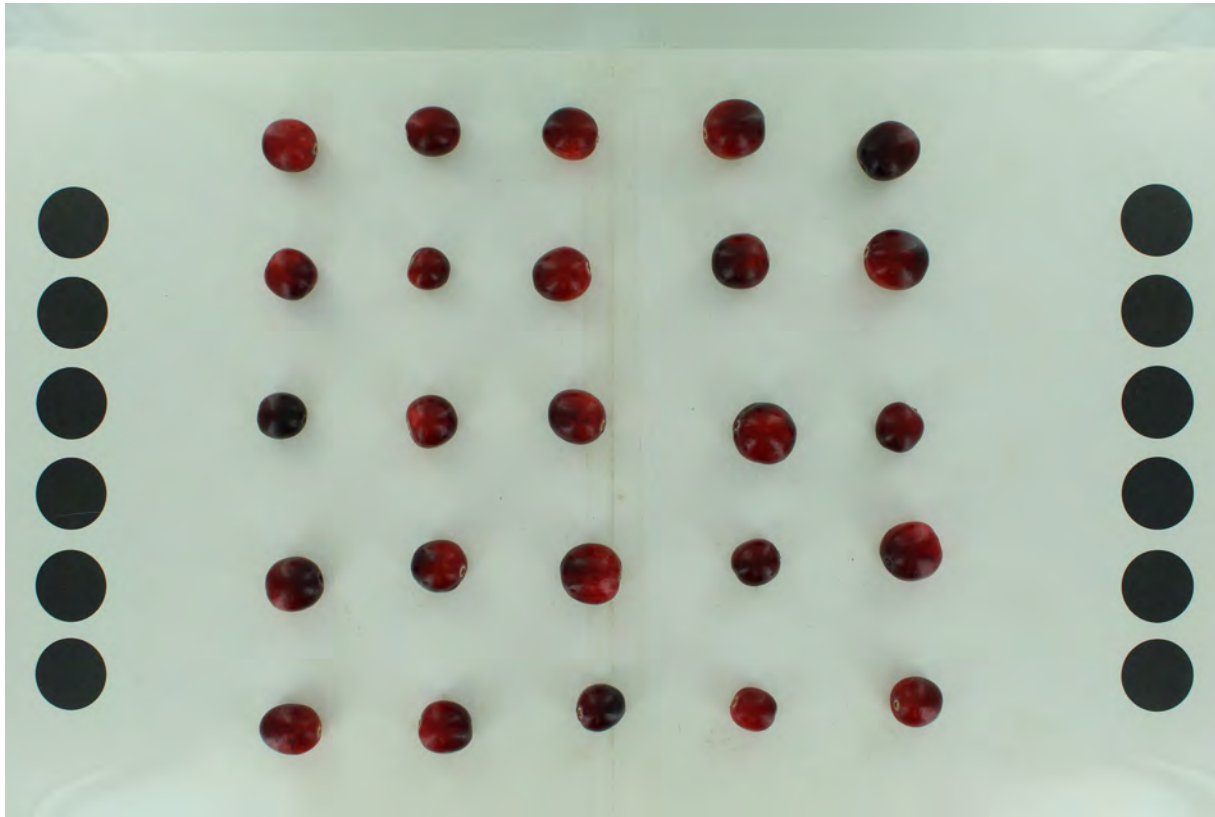
Midnight 8



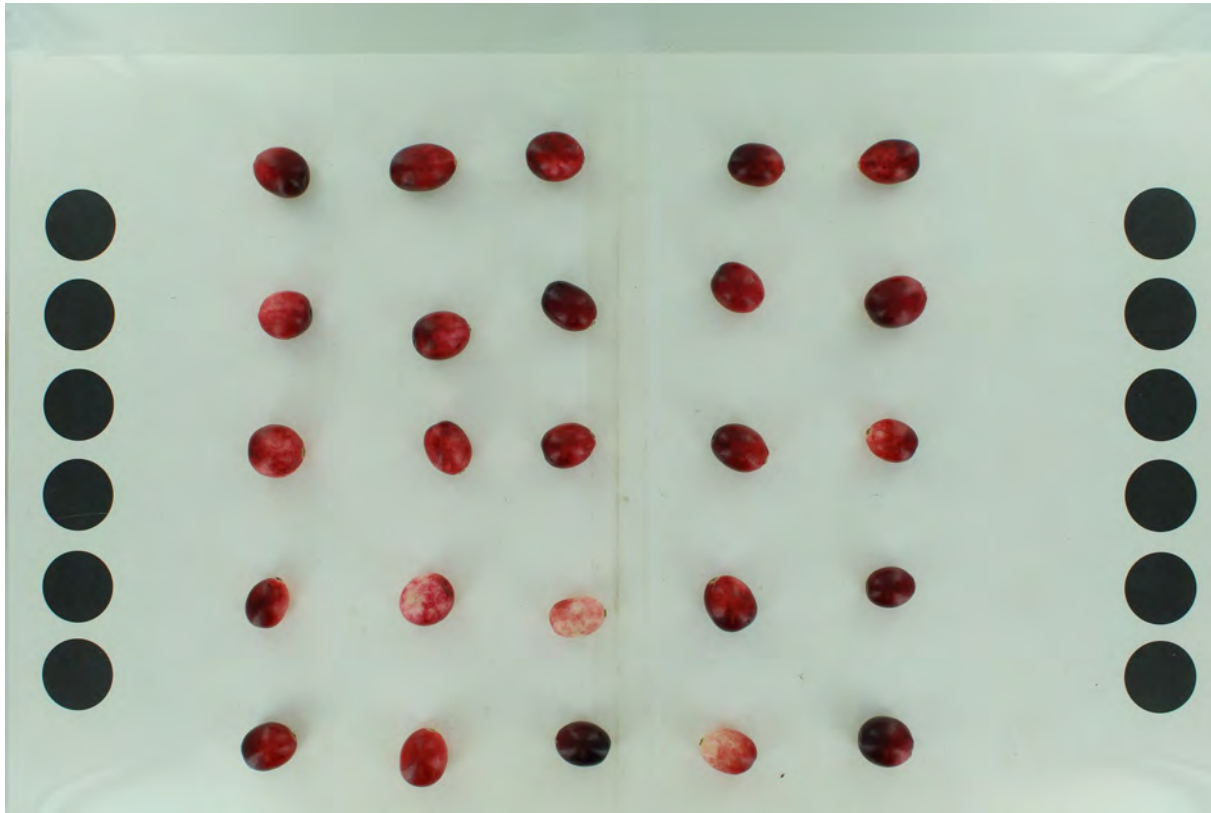
GH1



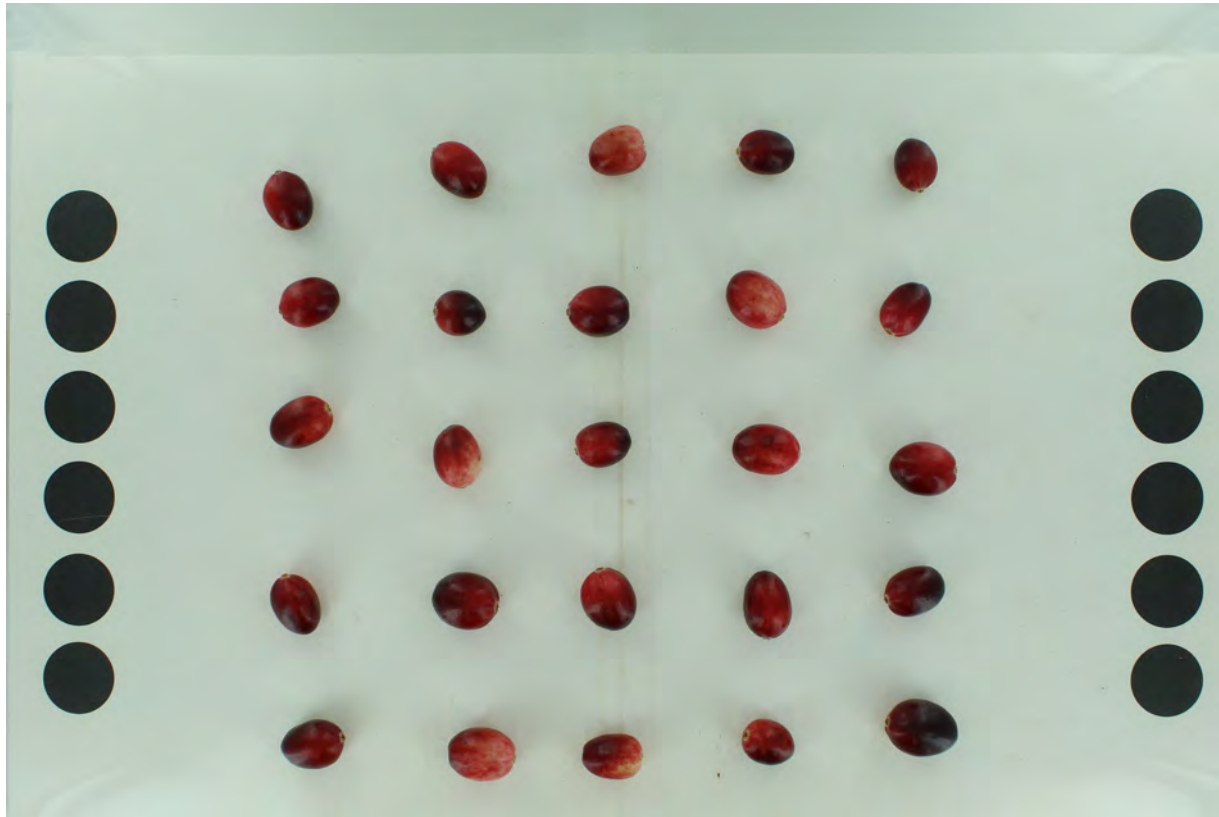
Pilgrim King



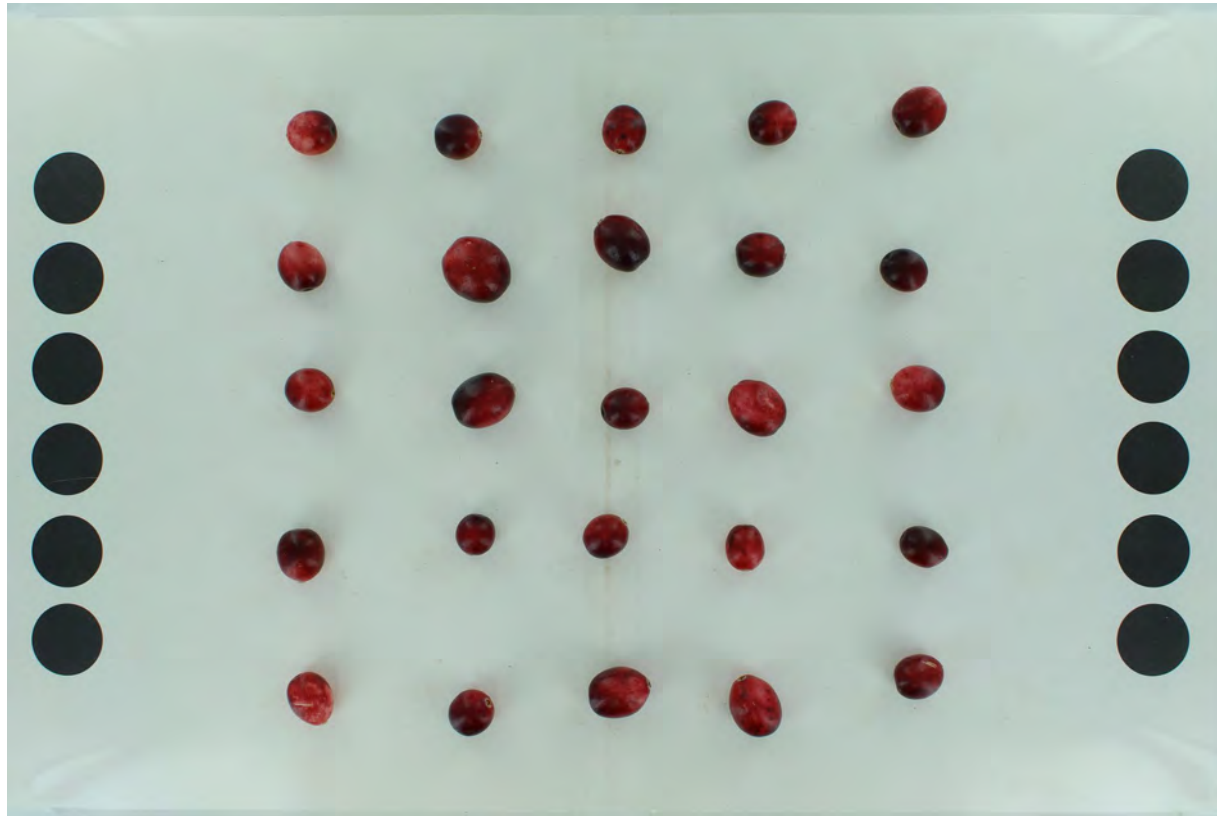
Stevens



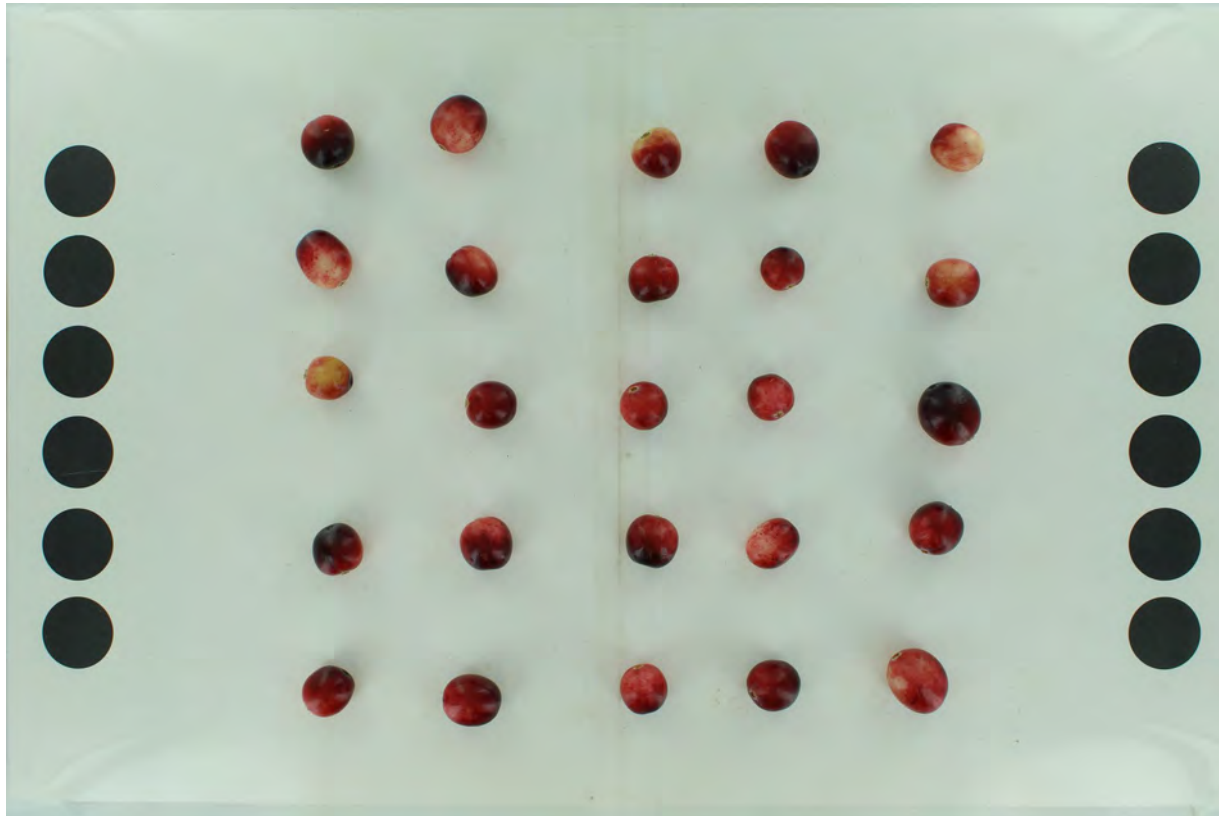
Sundance



BG



Granite Red



Trait mapping: Tacy and digital color

Yellow Bell hybrid

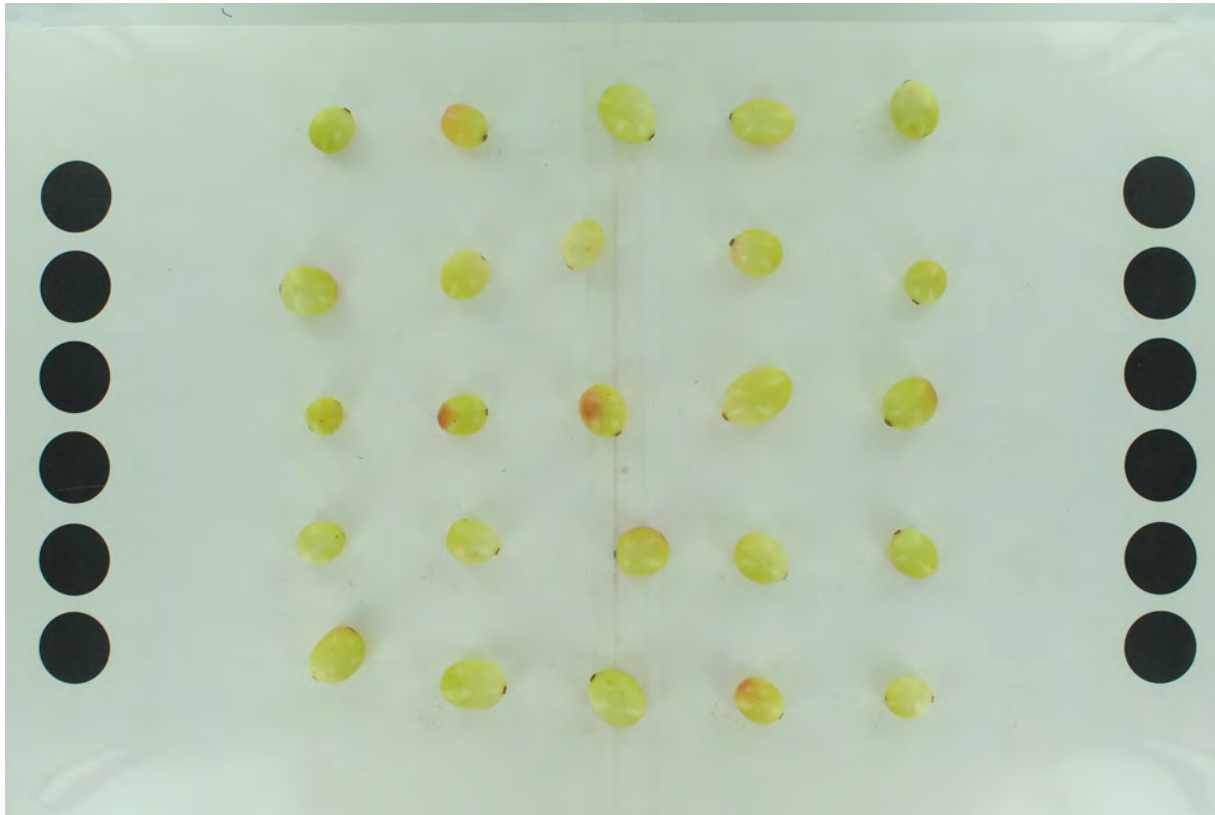
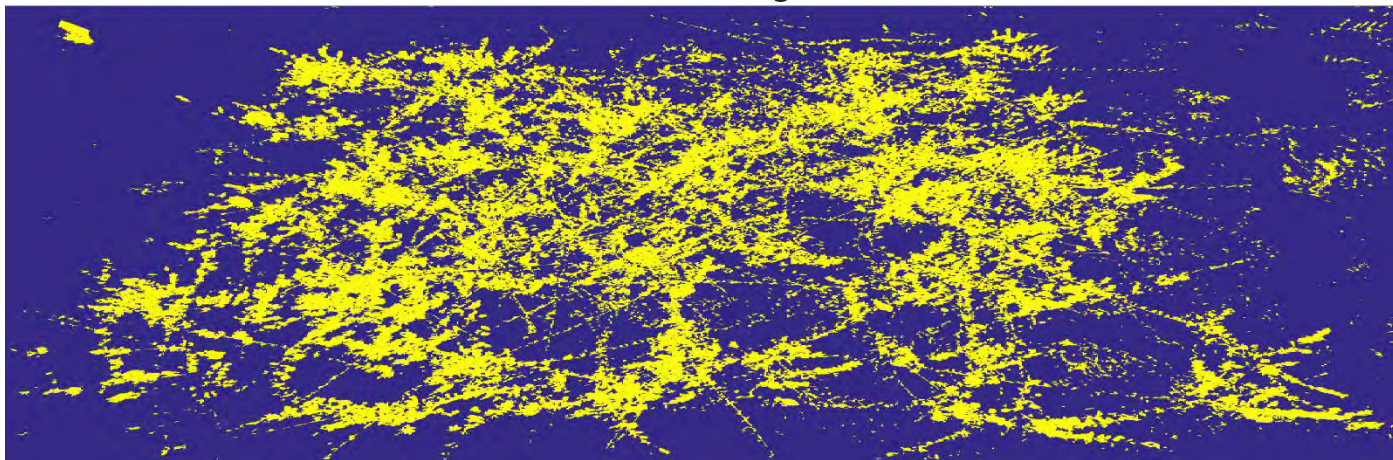


Image-based analysis of stolon growth during establishment

original resized picture



neural network-based background extraction



Example of upright yield



Plot yield



Example of plot yield







Other Fruit Quality Traits (SDC)

- Fruit Firmness

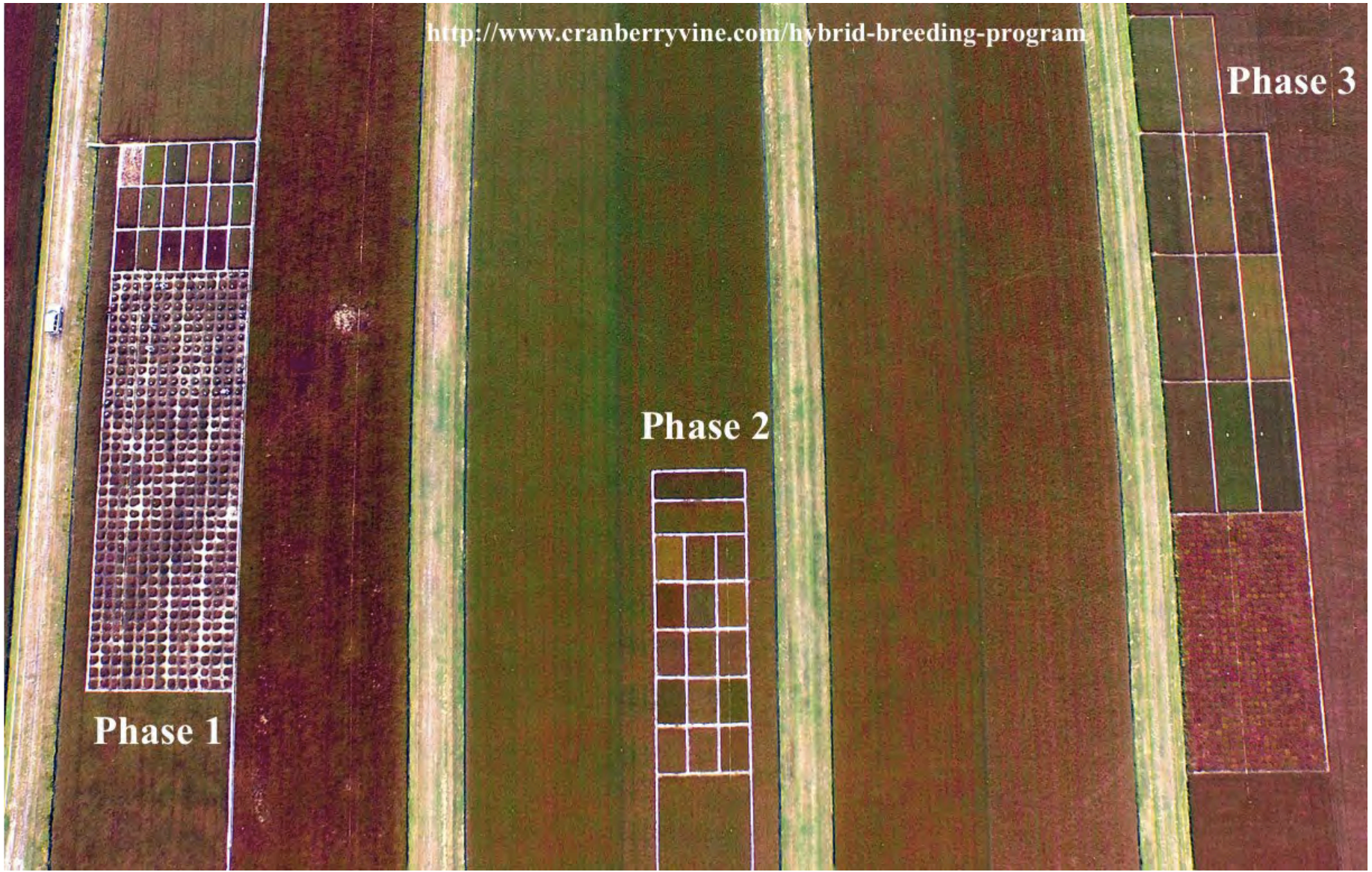


Self Breeding





<http://www.cranberryvine.com/hybrid-breeding-program>



Phase 1

Phase 2

Phase 3

<http://www.cranberryvine.com/hybrid-breeding-program>



<http://www.cranberryvine.com/hybrid-breeding-program>

<http://www.cranberryvine.com/hybrid-breeding-program>



Saddle Mound Introduction

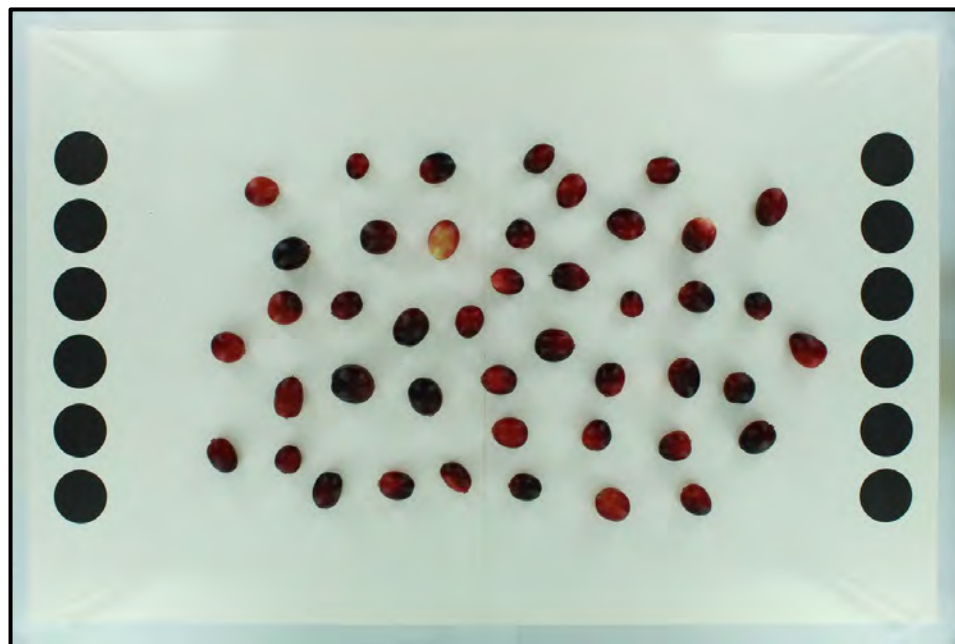
- 842 plants
- 7 “self” populations, with 683 plants total
 - 132 Pilgrim selfs
 - 166 Stevens selfs
 - 80 HyRed selfs
 - 127 Sundance selfs
 - 81 (Pilgrim x NLM) selfs
 - 95 Benlear selfs
- 73 unique wild (Wisconsin and Minnesota)
- 86 controls (81 Stevens, 4 #35, 1 Ben Lear)

- Augmented design

Field 2019



HyRed Self #193



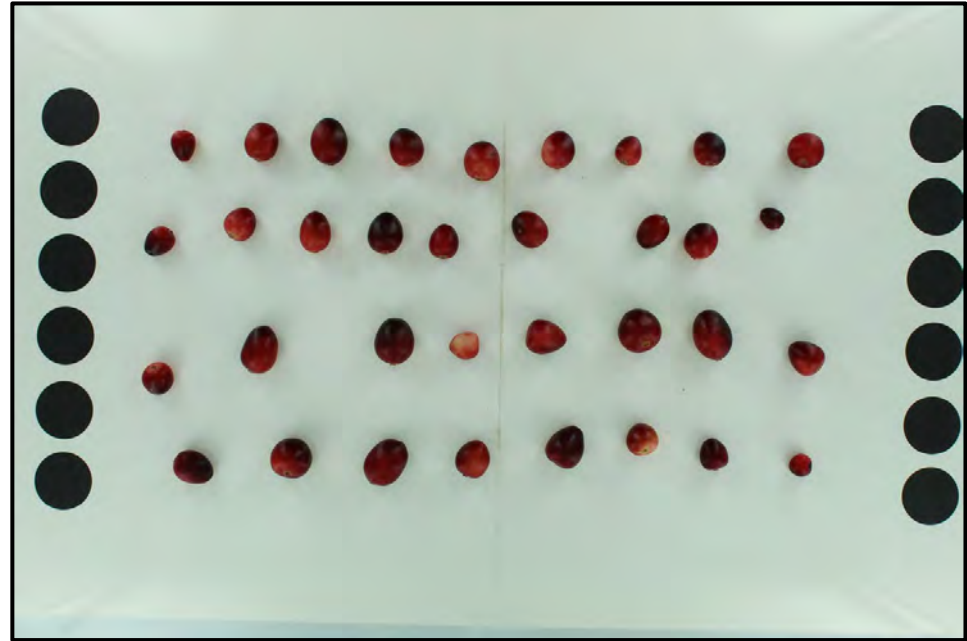
Sound Fruit Number	44
Sound Fruit Yield	54.62 g
Avg. Sound Fruit Weight	1.24 g

Sundance Self #65



Sound Fruit Number	25
Sound Fruit Yield	46.86 g
Avg. Sound Fruit Weight	1.87 g

Ben Lear Self #79



Sound Fruit Number	34
Sound Fruit Yield	42.13 g
Avg. Sound Fruit Weight	1.24 g

Plan development



Cranberry Research Station

Samples taken for DNA extraction for genetic testing of beds

Legend



Acknowledgements

**Cranberry Creek Cranberries
Valley Corporation
Saddle Mound Cranberry
Rutgers University**



**THE
CRANBERRY
INSTITUTE**



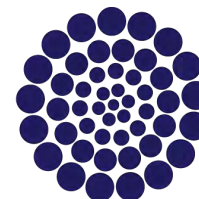
**Wisconsin
State
Cranberry
Growers
Association**

FOUNDED 1887



inifap

Instituto Nacional de Investigaciones
Forestales, Agrícolas y Pecuarias



CONACYT

Consejo Nacional de Ciencia y Tecnología