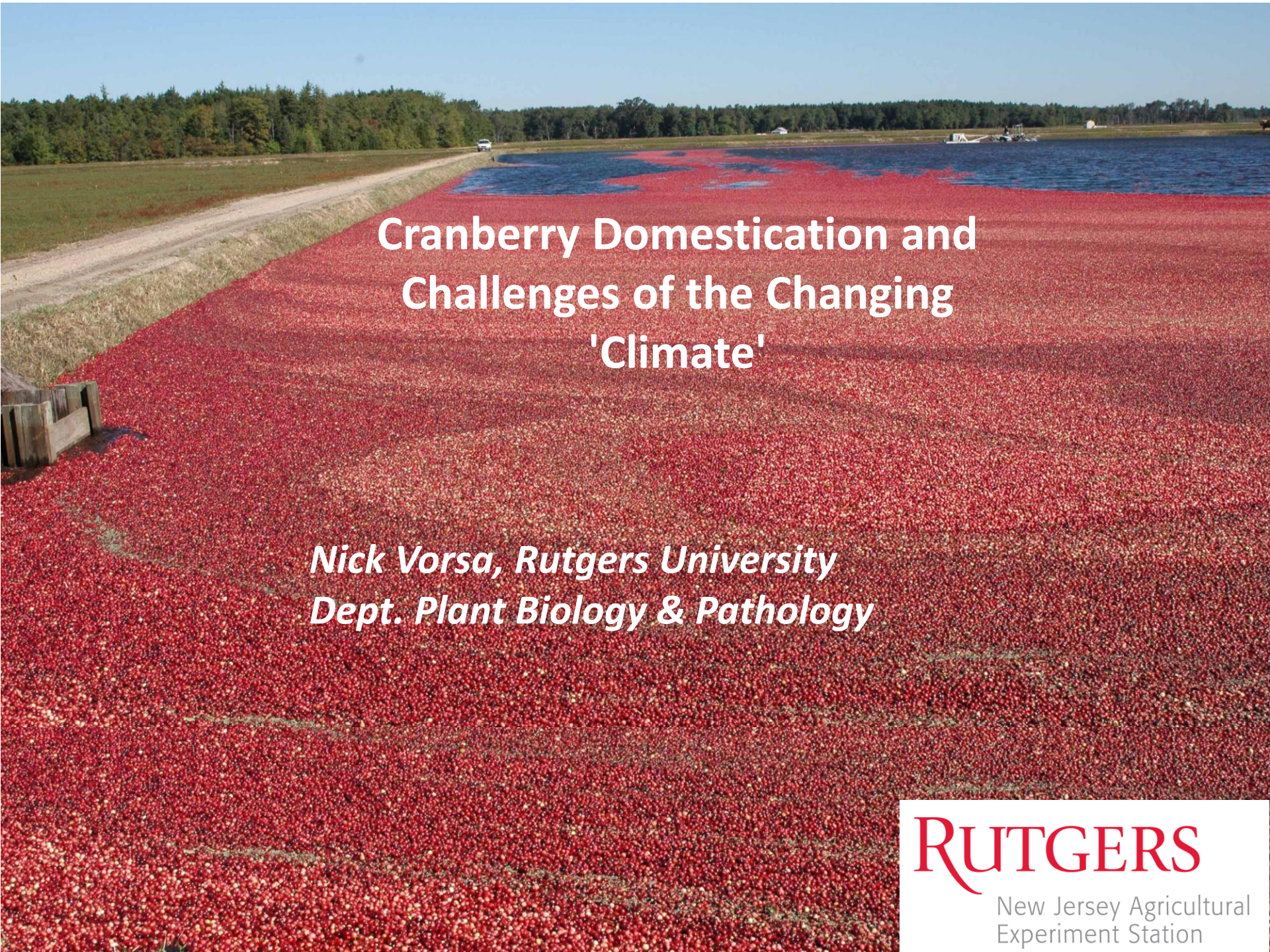


Cranberry Domestication and Challenges of the Changing 'Climate'

Nick Vorsa, Rutgers University
Dept. Plant Biology & Pathology

RUTGERS
New Jersey Agricultural Experiment Station

‘Climate’

Physiological

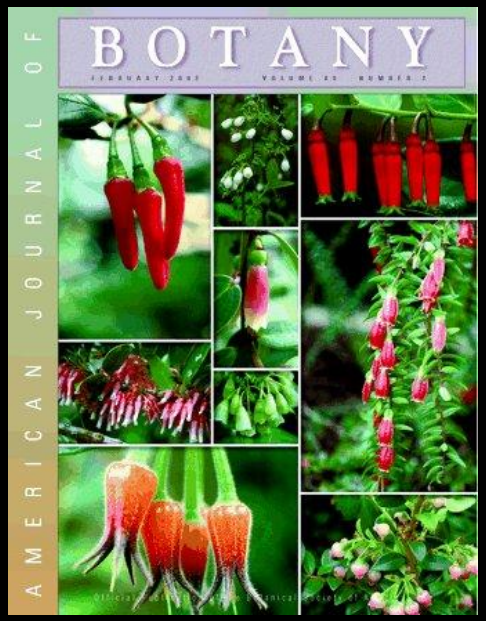
- Cranberry adaptation – chilling hrs?; heat stress

Disease & Insect Threats

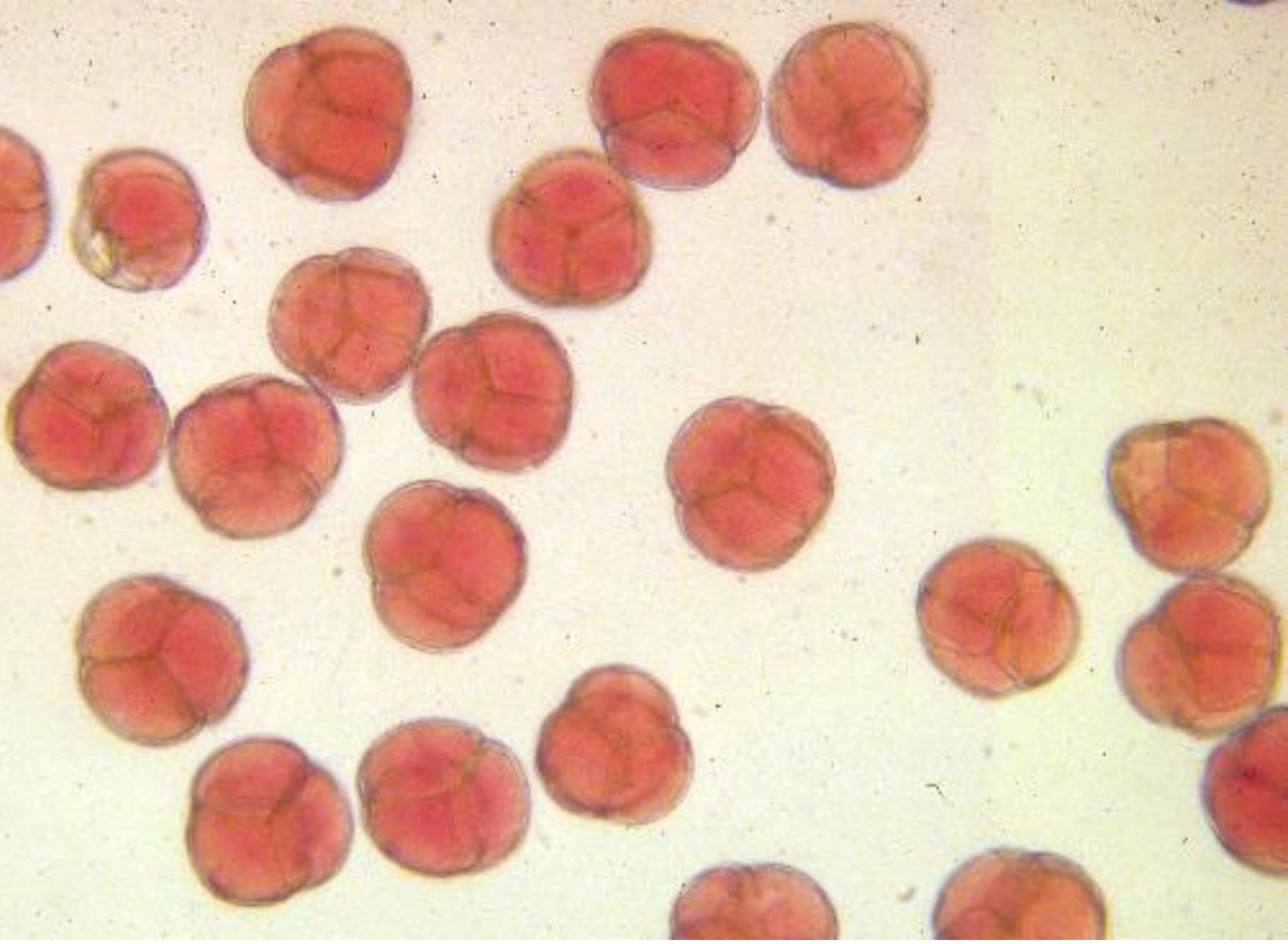
- Evolving insects pressure
- Evolving disease pressure

Business/sociological

- Juice vs. sweetend-dried
- Sugar
- Farming efficiency/sustainability



Acid soils pH 3 – 5.5



Highbush blueberry

V. corymbosum
Tetraploid
$2n = 4x = 48$

American cranberry

V. macrocarpon
Diploid
$2n = 2x = 24$

Asexual - stolons

Sexual - seeds

Fruit chemistry - Cranberry seed dispersal based on **animal or water**?

	Blueberry	Cranberry
Dispersal	**animal**	**Water**
buoyancy	**+/-**	**+**
Brix (soluble solids)	12 – 15%	7 – 10%`
Glucose+Fructose	7 – 10%	2 – 7%
main volatiles	Linalool Blueberry flavor	α – terpineol antiseptic
Acidity	Low TA (0.5 CAE)	High TA (2.5 CAE)
Benzoic Acid	0 %	~0.1%
Storage life	2 - 3 wks	3 - 6 months
Proanthocyanidins	+/-	++++

Meiosis in cv. Wilcox

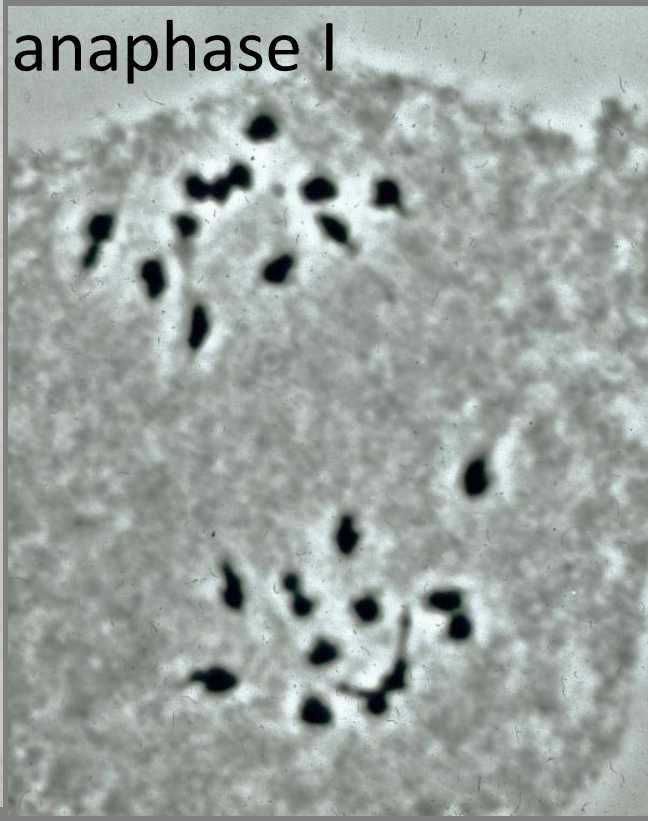
diakinesis

Cranberry

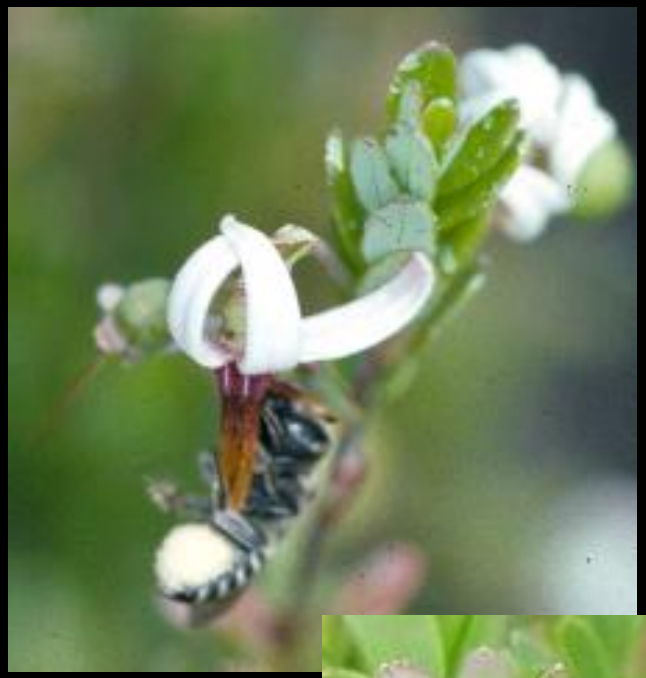
$2n = 2x = 24$

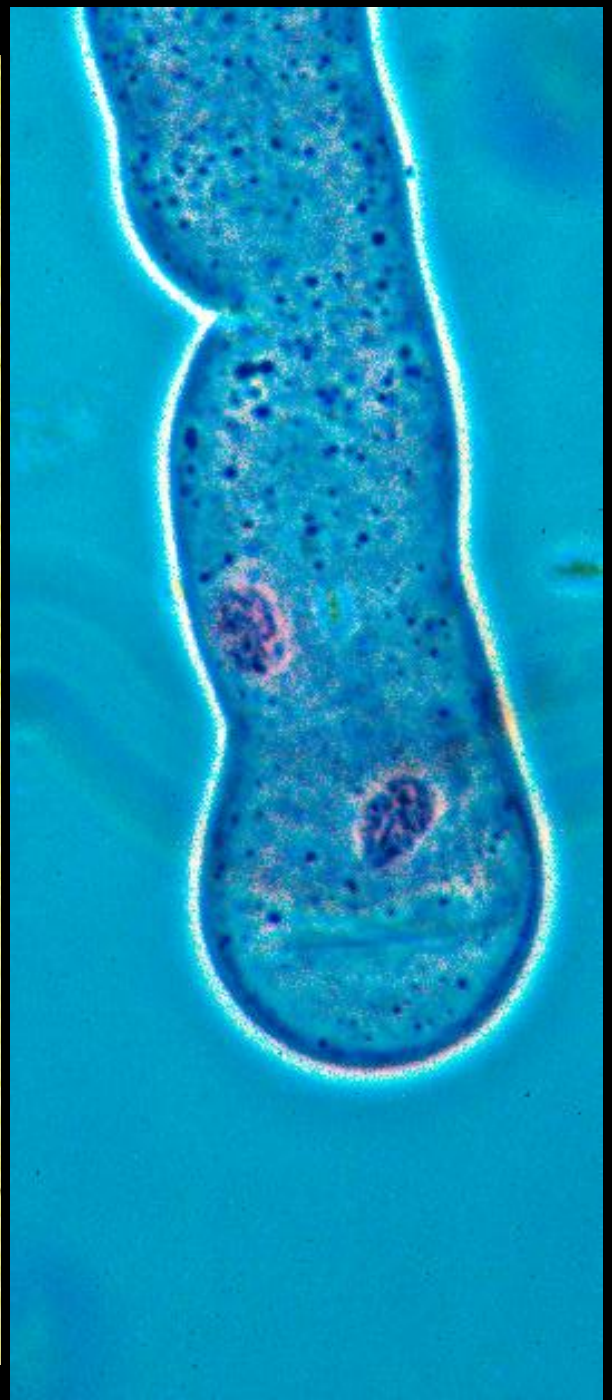
genome 570 Mbp

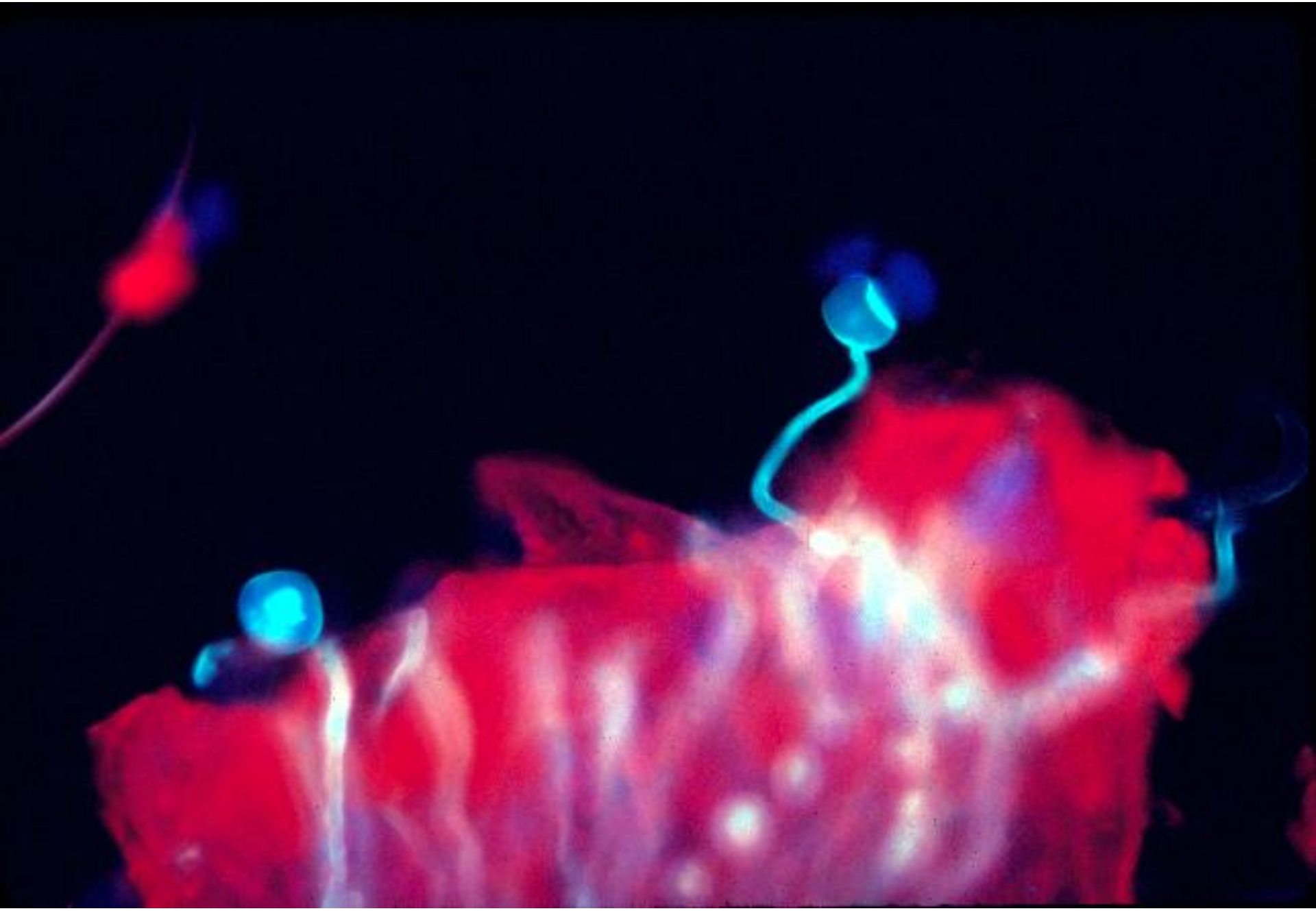
anaphase I



protandry







Pilgrim line

Ben Lear line

Industry still cultivates native cultivars

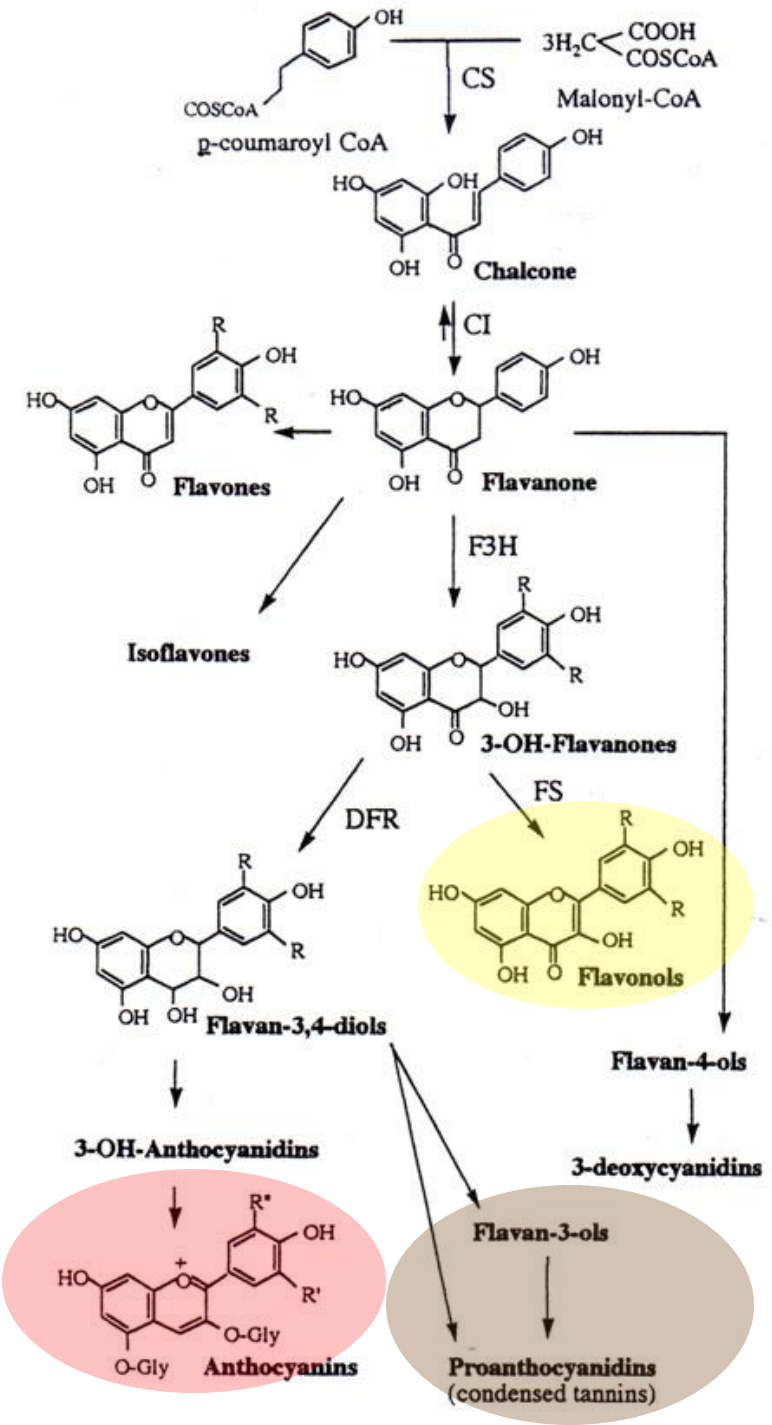
Early Black	**1852**	**MA**
Howes	**1843**	**MA**
Searles	**1893**	**WI**
McFarlin	**1874**	**MA**
Lemunyon	**1870's**	**NJ**
Ben Lear	**1907**	**WI**

cv. Early Black – 1852 Harwich, MA

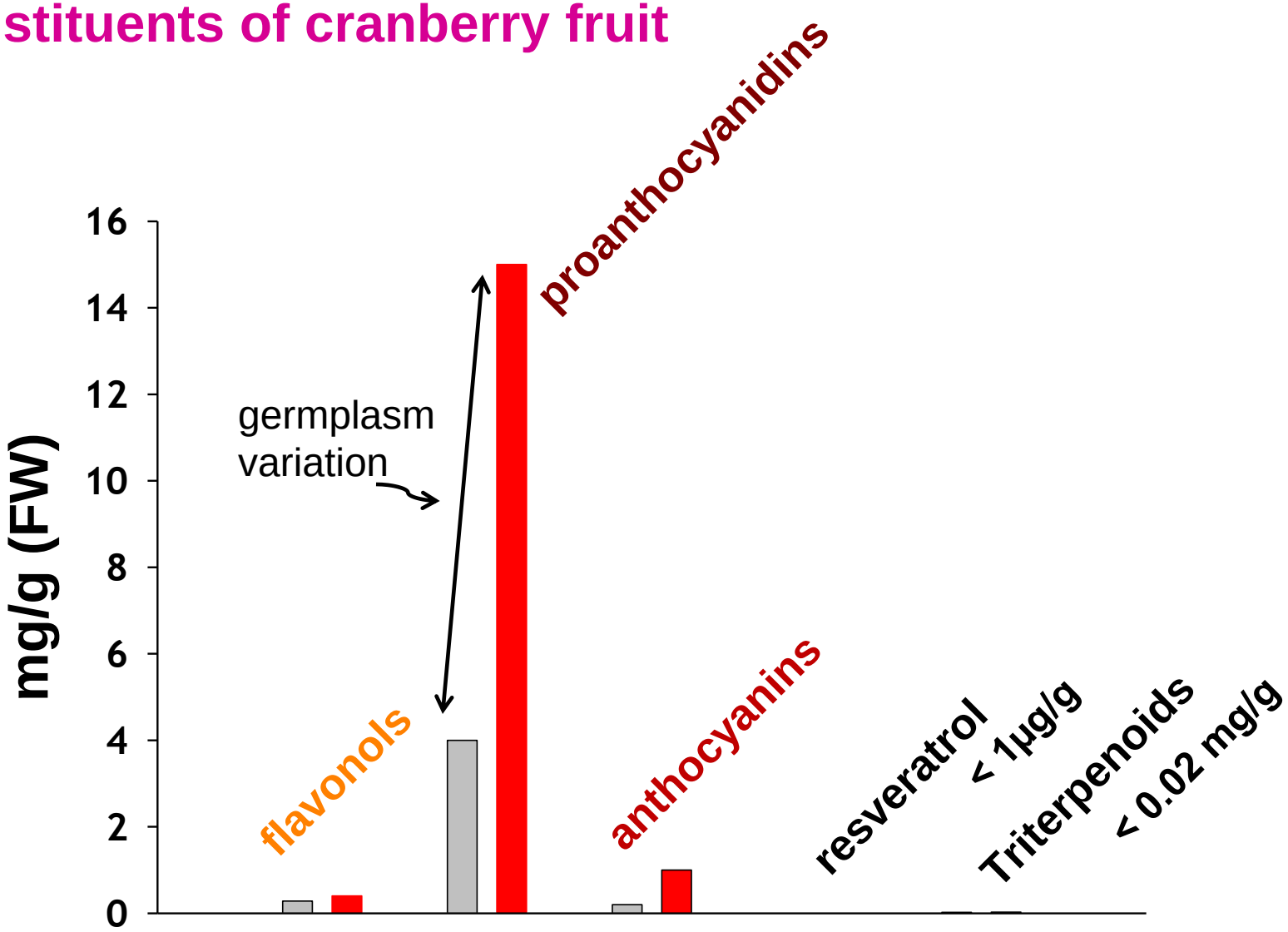
Flavonoid biosynthetic pathway

Shikimic acid pathway

- Anthocyanins
- Flavonols
- Flavan-3-ols
- Proanthocyanidins



Constituents of cranberry fruit

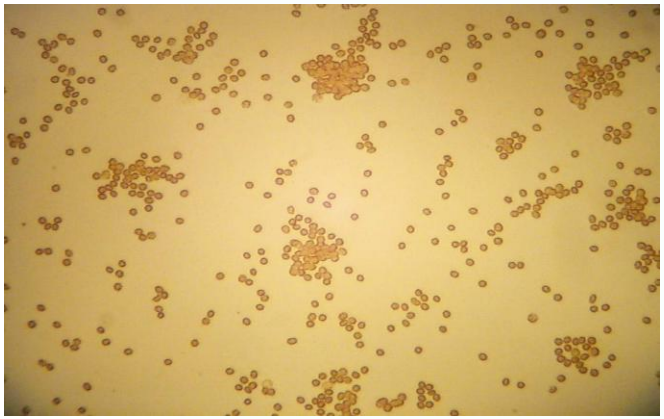


A-Type Proanthocyanidin Trimers from Cranberry that Inhibit Adherence of Uropathogenic P-Fimbriated *Escherichia coli*

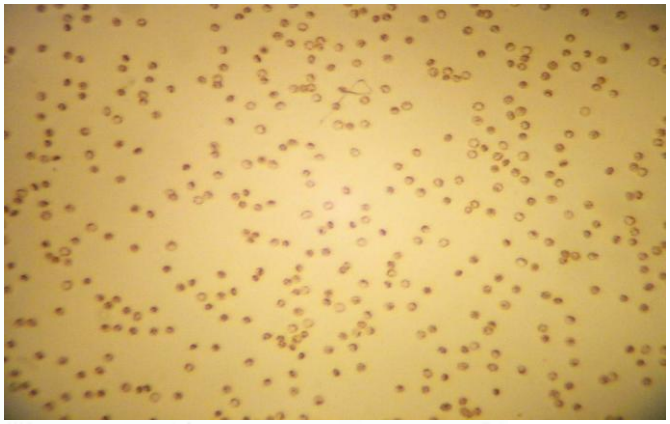
L. Yeap Foo, Yinrong Lu, Amy B. Howell, and Nicholi Vorsa

Industrial Research, Gracefield Research Center, PO Box 31-310, Lower Hutt, New Zealand, and Philip E. Marucci Center for Blueberry and Cranberry Research, Rutgers University, Chatsworth, New Jersey 08019

RBC, P type *E.coli*
- Cranberry extract



RBC, P type *E.coli*
+ Cranberry extract



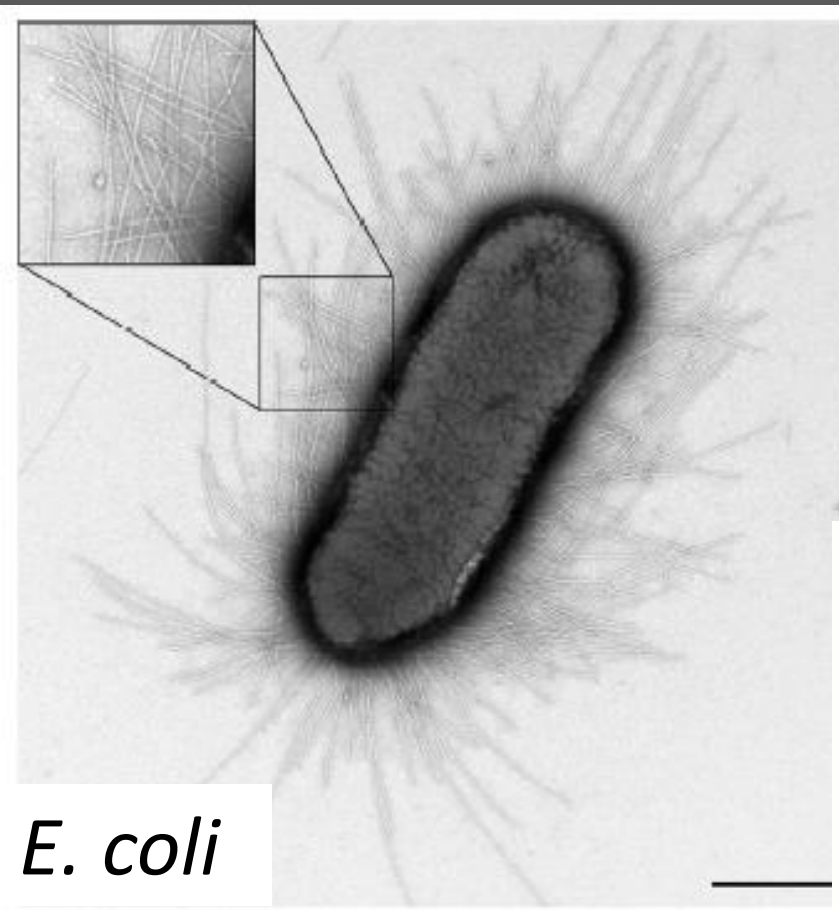
JOURNAL OF NATURAL PRODUCTS®

Urinary tract disease

E. Coli tyes

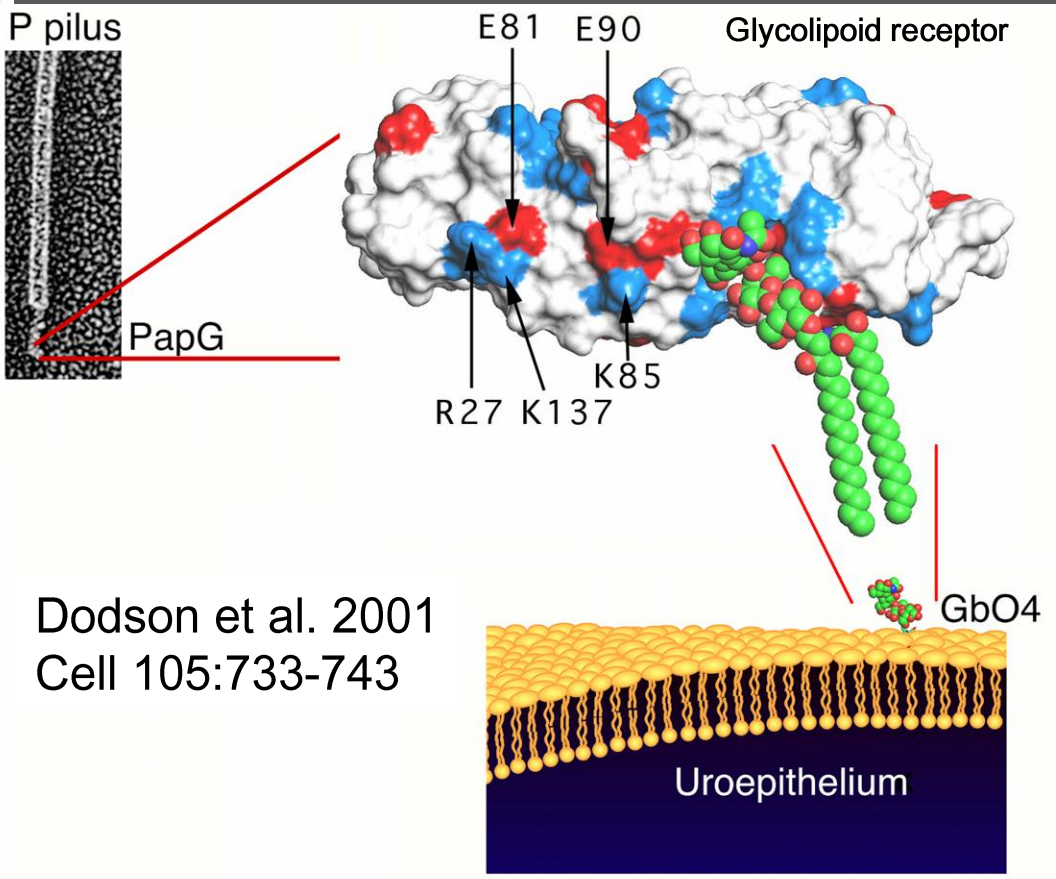
type-1 cystitis

P-type pyelonephritis



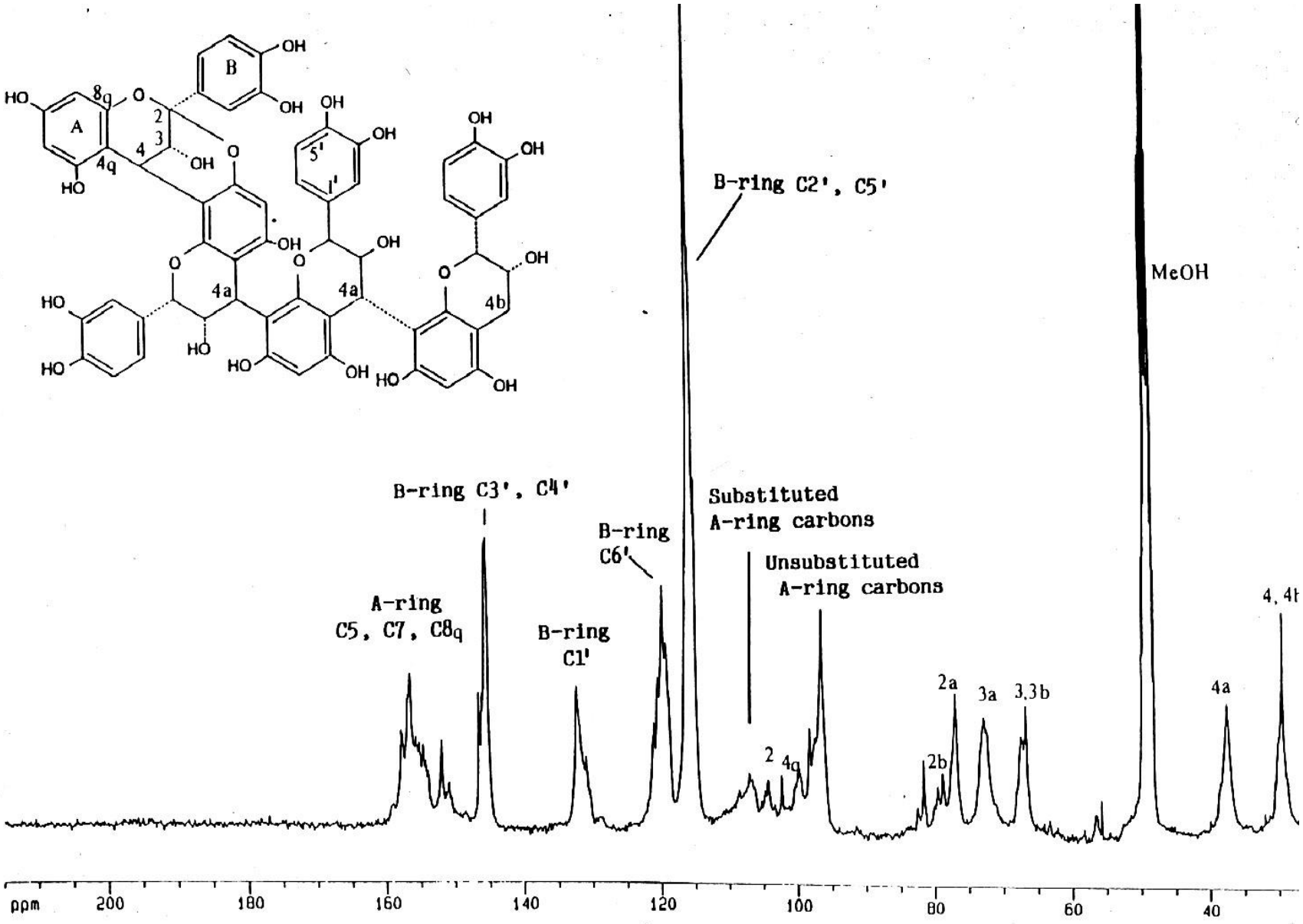
E. coli

Hahn et al. 2002
J. Mol. Biol. 323:845



Dodson et al. 2001
Cell 105:733-743

A-type proanthocyanidins



J. Nat. Prod. **2000**, *63*, 1225−1228

A-Type Proanthocyanidin Trimers from Cranberry that Inhibit Adherence of Uropathogenic P-Fimbriated *Escherichia coli*

L. Yeap Foo,*,† Yinrong Lu,† Amy B. Howell,‡ and Nicholi Vorsa‡

Caries Research

Caries Res 2010;44:116–126
DOI: 10.1159/000296306

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Published

PHYTOTHERAPY RESEARCH
Phytother. Res. **23**, 1066–1074 (2009)
Published online 26 January 2009 in Wiley InterScience
(www.interscience.wiley.com) **DOI**: 10.1002/ptr.2667

Cranberry Proanthocyanidins are Cytotoxic to Human Cancer Cells and Sensitize Platinum-Resistant Ovarian Cancer Cells to Paraplatin

Ajay P. Singh[1,2,ψ], Rakesh K. Singh[ψ,3], Kyu Kwang Kim[3], K. S. Satyan[4], Roger Nussbaum[1], Monica Torres[1], Laurent Brard[3]* and Nicholi Vorsa[1,2]*

Influence of Cranberry Proanthocyanidins on Formation of Biofilms by *Streptococcus mutans* on Saliva-Coated Apatitic Surface and on Dental Caries Development in vivo

H. Koo[a–c] S. Duarte[a] R.M. Murata[a] K. Scott-Anne[b] S. Gregoire[b]
G.E. Watson[a] A.P. Singh[d] N. Vorsa[d, e]

INTERNATIONAL JOURNAL OF ONCOLOGY

Purified cranberry proanthocyanidines (PAC-1A) cause pro-apoptotic signaling, ROS generation, cyclophosphamide retention and cytotoxicity in high-risk neuroblastoma cells

AJAY P. SINGH[1,2], THILO S. LANGE[3,4], KYU K. KIM[3], LAURENT BRARD[5], TIMOTHY HORAN[3], RICHARD G. MOORE[3], NICHOLI VORSA[1,2] and RAKESH K. SINGH[3]

INTERNATIONAL JOURNAL OF ONCOLOGY 46: 1924-1934, 2015

The cranberry flavonoids PAC DP-9 and quercetin aglycone induce cytotoxicity and cell cycle arrest and increase cisplatin sensitivity in ovarian cancer cells

YIFEI WANG[1], ALEX HAN[2], EVA CHEN[2], RAKESH K. SINGH[2], CLINTON O. CHICHESTER[3], RICHARD G. MOORE[2], AJAY P. SINGH[1] and NICHOLI VORSA[1,4]

OPEN ACCESS Freely available online

PLoS one

Insights into the Molecular Mechanisms of the Anti-Atherogenic Actions of Flavonoids in Normal and Obese Mice

Elena V. Shabrova[1,4], Olga Tarnopolsky[1], Ajay P. Singh[1], Jorge Plutzky[2], Nicholi Vorsa[1,3]*, Loredana Quadro[4]*

1st breeding and selection cycle – initiated in 1929

USDA with New Jersey and Massachusetts Agricultural Experiment Stations

Cranberry Breeding Investigation of the U. S. Dept. of Agriculture

F. B. CHANDLER, R. B. WILCOX, H. F. BAIN, H. F. BERGMAN, and HAIG DERMEN (1)

New Jersey was chosen for the first nursery study of the seedlings, as false blossom spreads more rapidly there than in the other states.

aim of originating varieties that would show resistance to the spread of false-blossom disease and that would produce large crops of superior fruit.

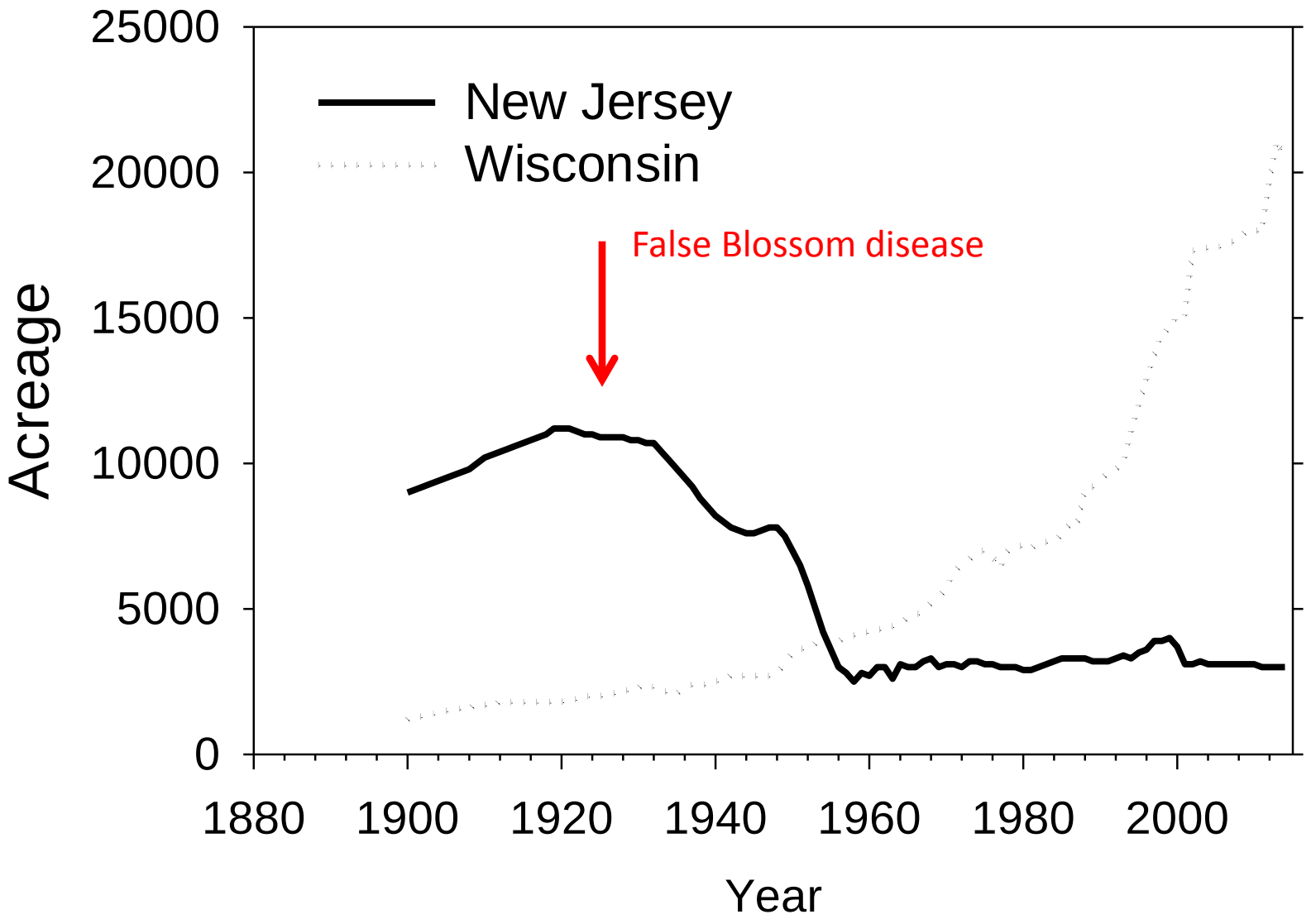
Cranberries
THE NATIONAL CRANBERRY MAGAZINE

May, 1947

> 10,000 seedlings from 46 crosses → 40 selections

6 Cultivars named

Stevens, **Pilgrim**, Bergman, Beckwith, Wilcox, Franklin


25000
20000
15000
10000
5000
0
Acreage
New Jersey
Wisconsin
False Blossom disease
1880
1900
1920
1940
1960
1980
2000
Year

Fruit rot

2000-present cranberry breeding objectives

Desirable horticultural traits

Fruit Rot Resistance (warmer climate)

Yield

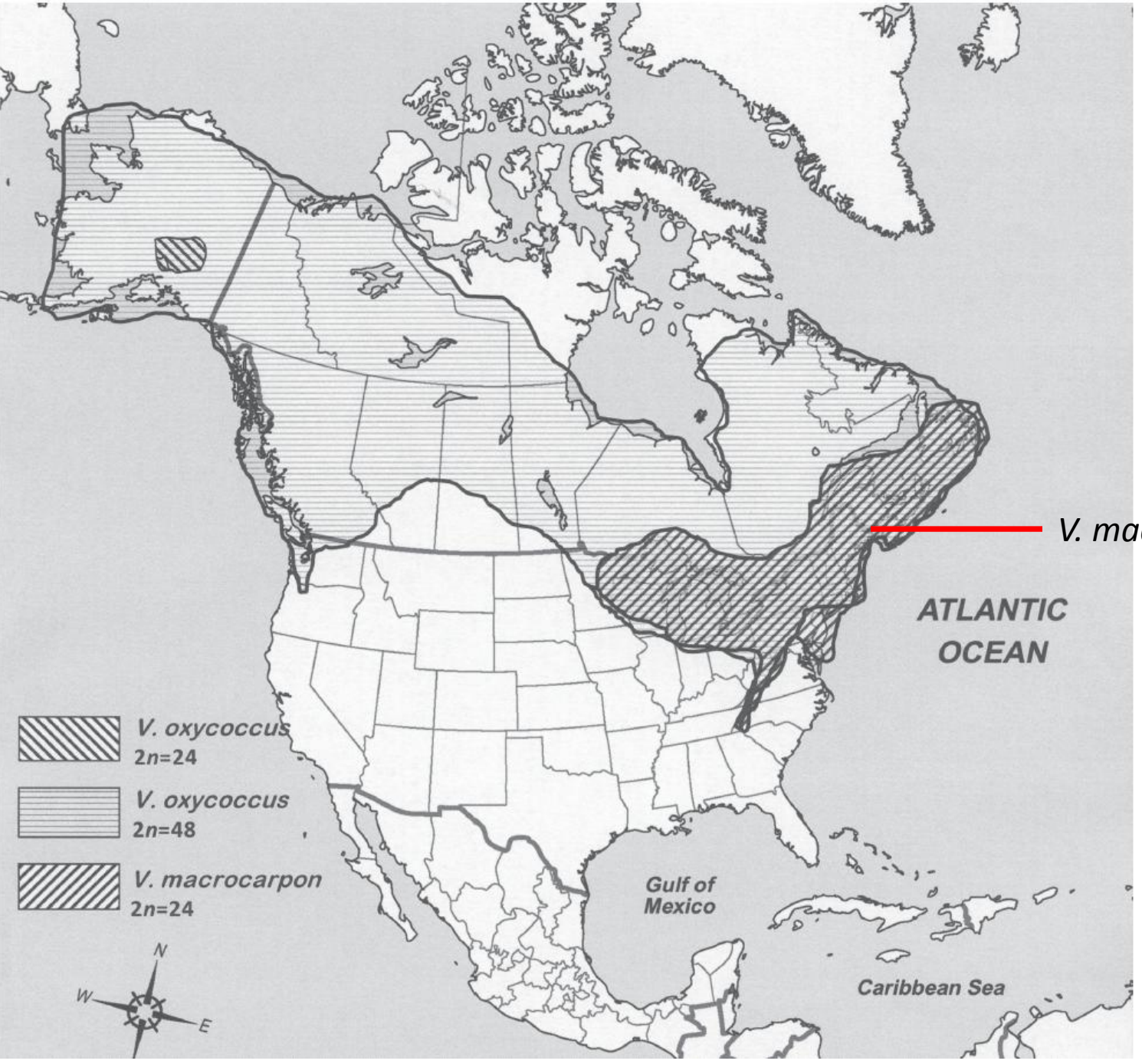
Season of ripening

Juice vs. sweeten-dried cranberry (SDC)

Processing requirements

- Tacy (fruit anthocyanidins)
- Round fruit shape
- Large fruit size
- Fruit firmness
- Early/late season ripening

Cranberry Germplasm



Germplasm – genetic resources

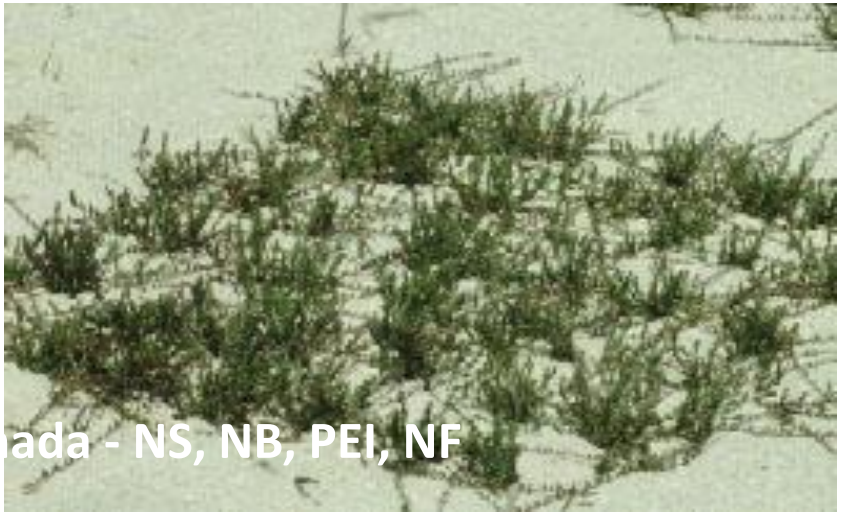
Gene pool

genetic resources,
or more precisely the DNA of an organism
and collections of that material

Domesticated germplasm – NJ, MA and WI

Native germplasm - DE, NJ, NY, MA, ME, WV, PA, MI, WI, MN

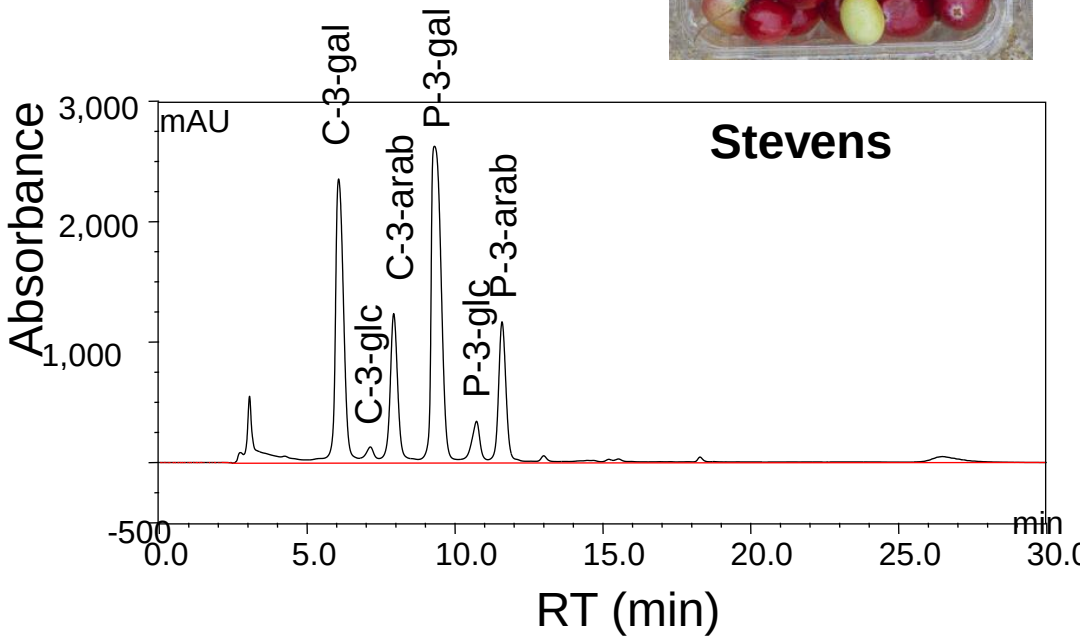
> 600 accessions



RUTGERS
New Jersey Agricultural Experiment Station

Fruit of germplasm evaluated in 1998 for:

Berry Wt		Total Phenolics	
Yield		TotalP PACs	
TA		Tacy	
Citric Acid		Cyan3Gal	
Malic Acid		Cyan3Glu	
Quinic Acid		Cyan3Arab	
Brix		Peon3Gal	
Glucose		Peon3Glu	
Fructose		PeonArab	
Sucrose			

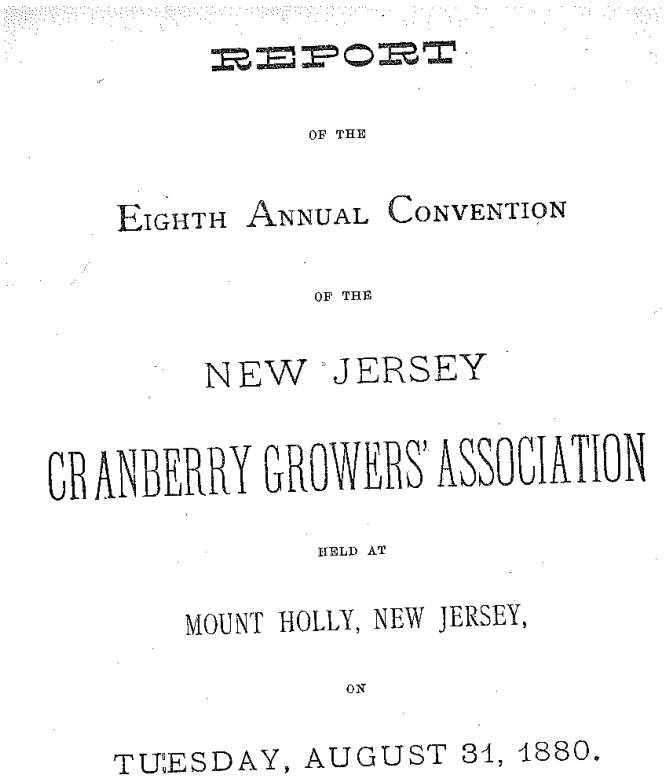


HPLC @ OSC, Inc.

Breeding cranberry for fruit rot resistance – The impossible dream?

Nicholi Vorsa

Jennifer Johnson-Cicalese



REPORT

OF THE

EIGHTH ANNUAL CONVENTION

OF THE

NEW JERSEY

CRANBERRY GROWERS' ASSOCIATION

HELD AT

MOUNT HOLLY, NEW JERSEY,

ON

TUESDAY, AUGUST 31, 1880.

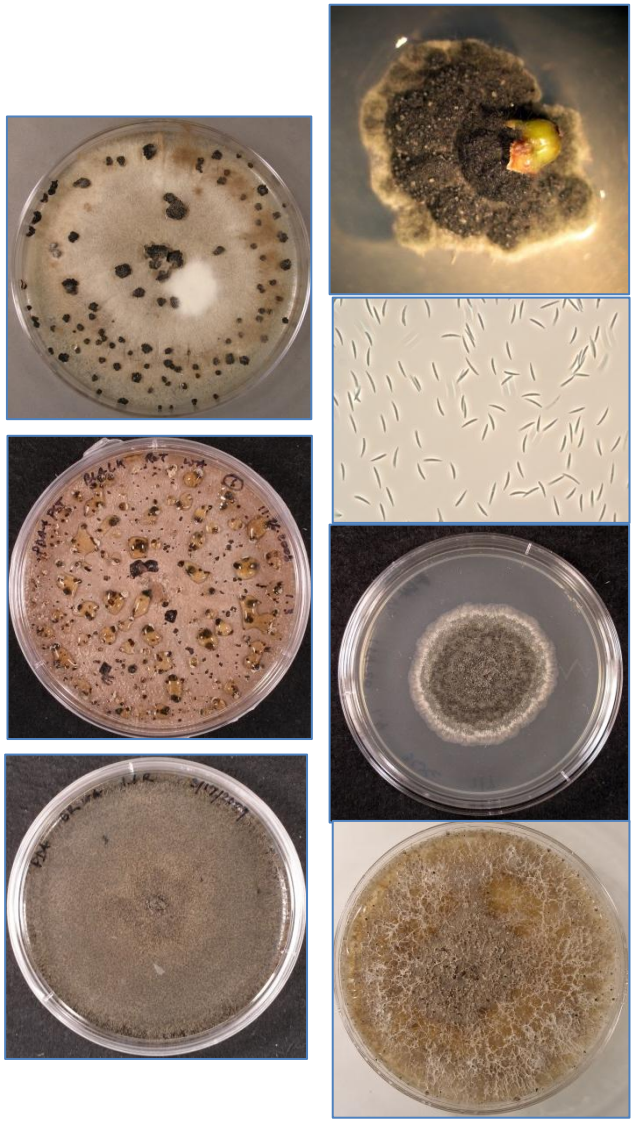
Prof. Geo. H. Cook, Superintendent of the State Experiment Station, then gave the result of his examination into the cause and cure of the cranberry rot. He said:

RUTGERS

New Jersey Agricultural Experiment Station

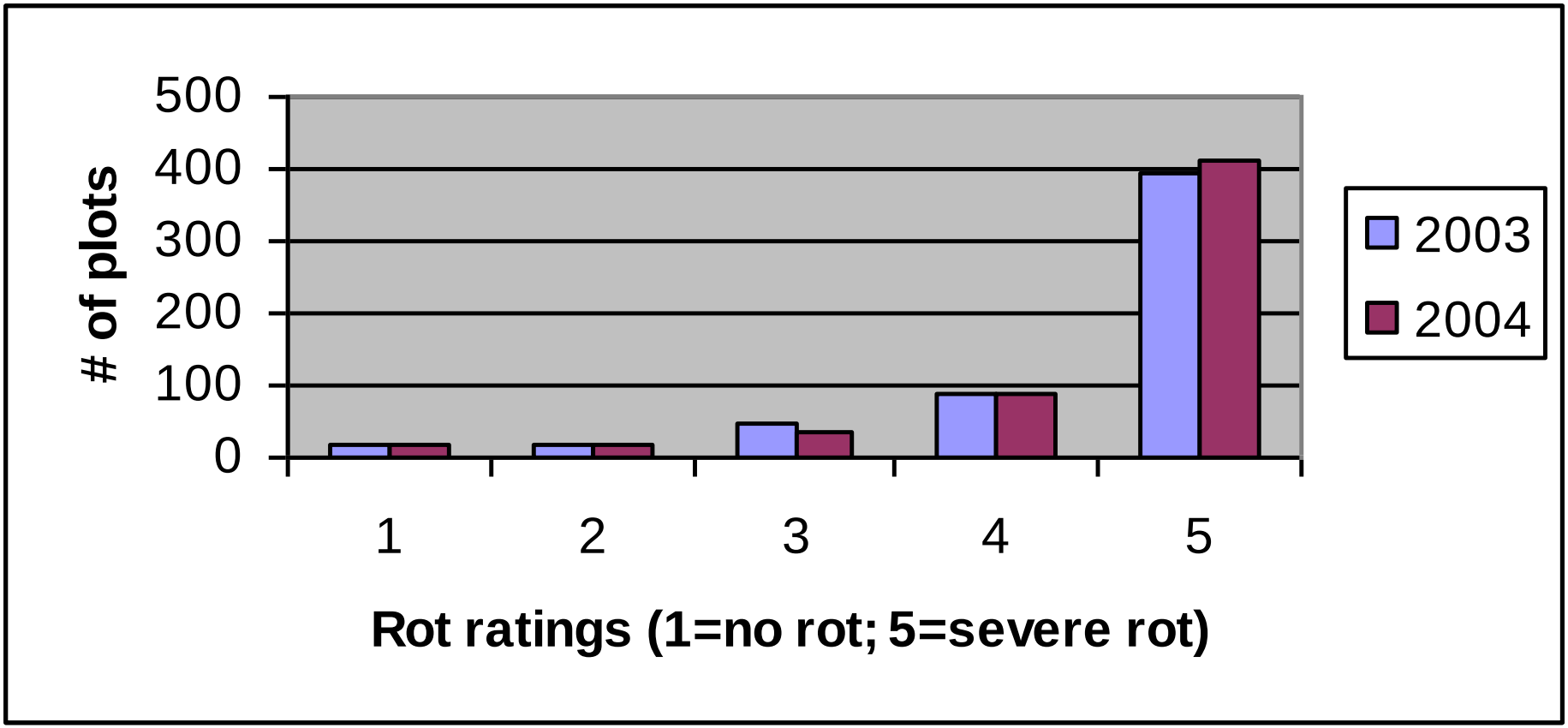
Resistance to
Fungi causing cranberry fruit rot disease complex

- *Coleophoma empetri*
- *Colletotrichum accutatum*
- *Colletotrichum* cf. *gloeosporioides*
- *Fusicoccum putrefaciens*
- *Monilinia oxycocci*
- *Phomopsis vaccinii*
- *Phyllosticta vaccinii*
- *Physalospora vaccinii*



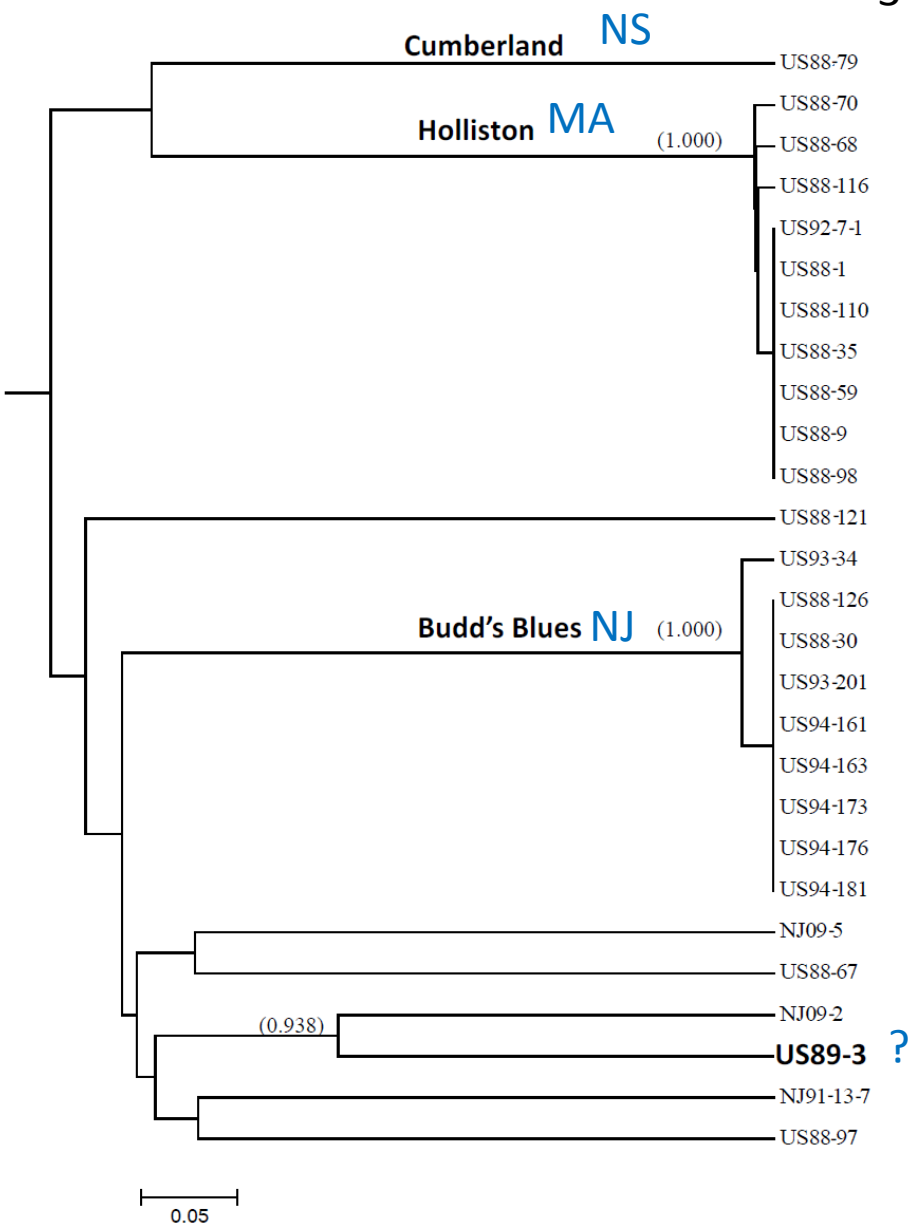
Oudemans et al. *Plant Disease* 82:1176-84, 1998

Germplasm Evaluation



When fungicides were withheld from our germplasm collection, most accessions were highly susceptible to fruit rot (rating of 5), but a few showed resistance both years.

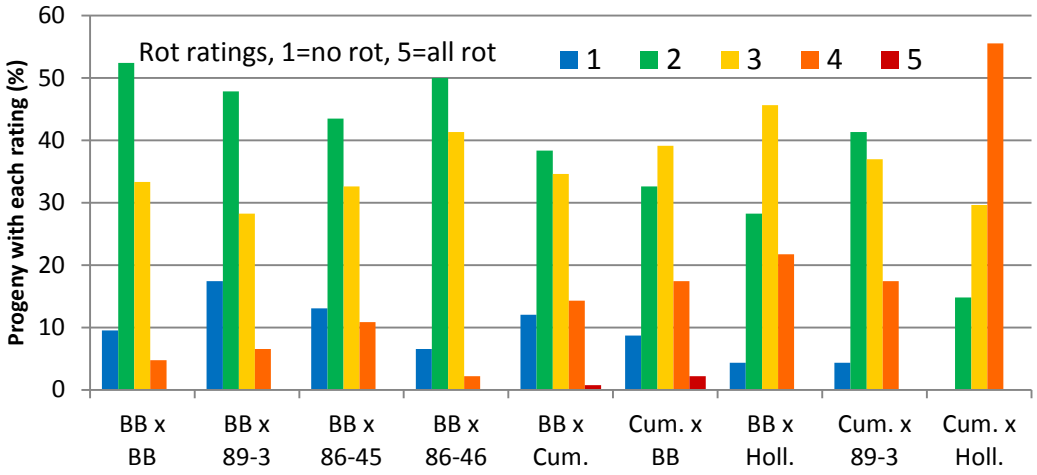
34 simple sequence repeats (SSR)



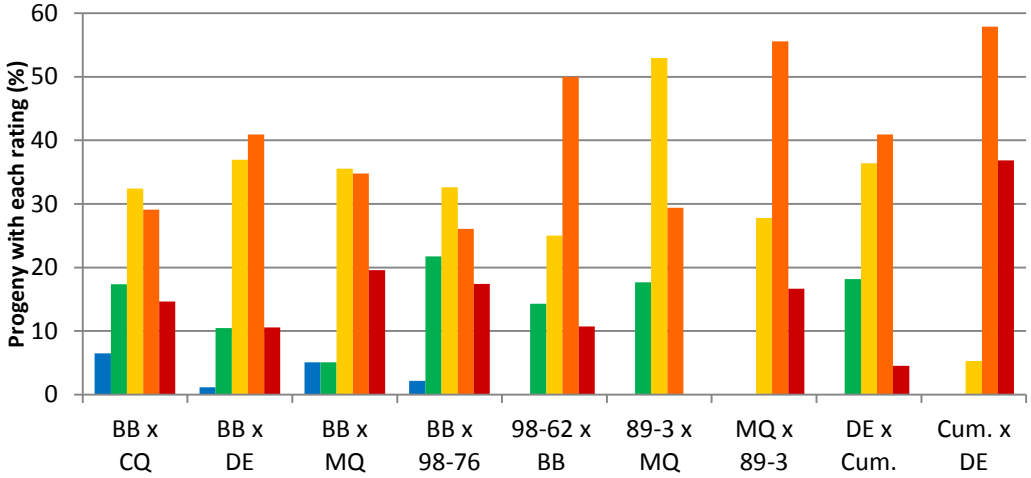
Bog 4 germplasm

Budd’s Blues

Populations segregating for fruit rot



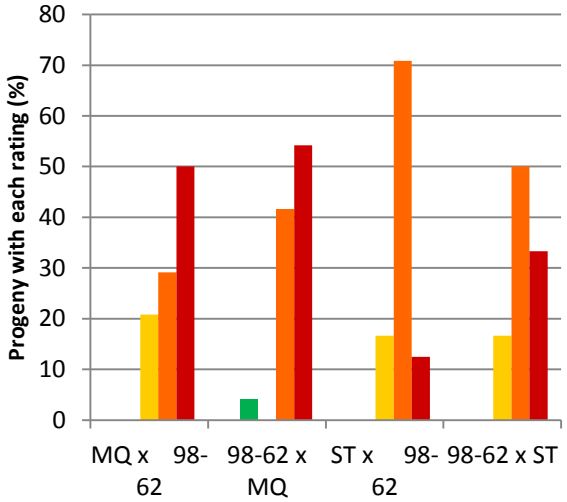
Resistant x resistant



Resistant x susceptible

Res. Clones

BB – Budds Blues
Holl. – Holliston
89-3

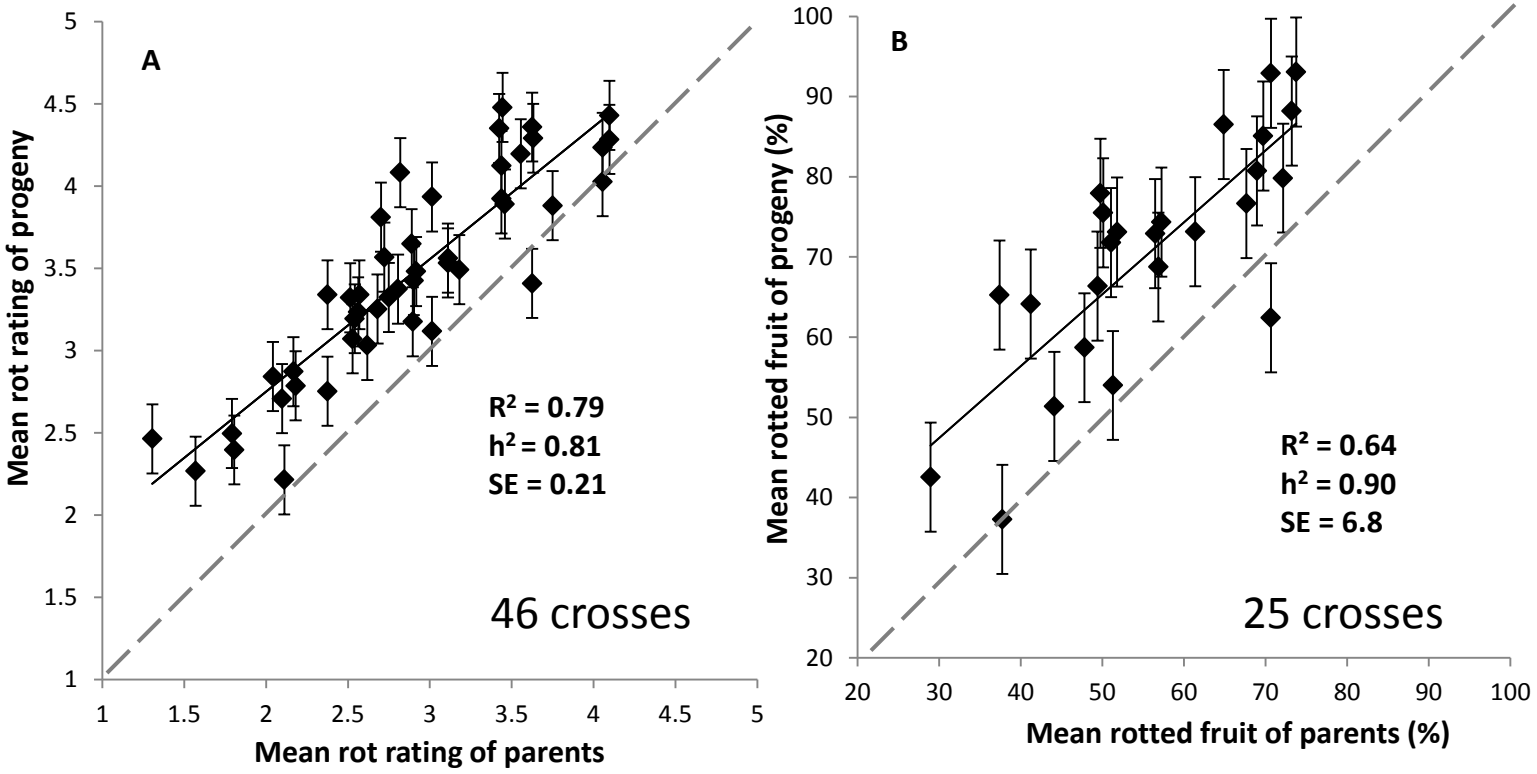


Susceptible x susceptible

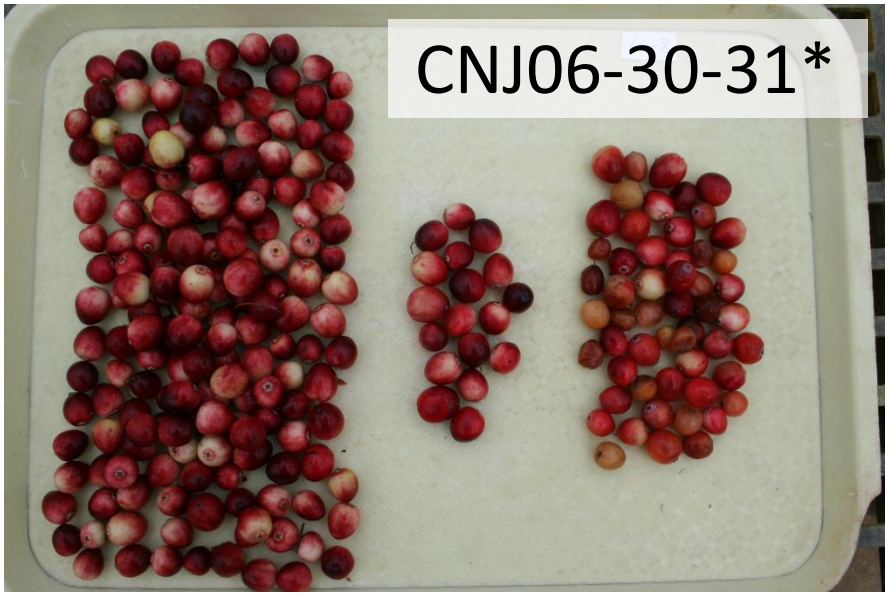

2009 12 ac of progeny plots, Marucci Center
© 2012 Google
Imagery Date: 9/20/2010
39°42'46.27" N 74°30'32.27" W elev 51 ft

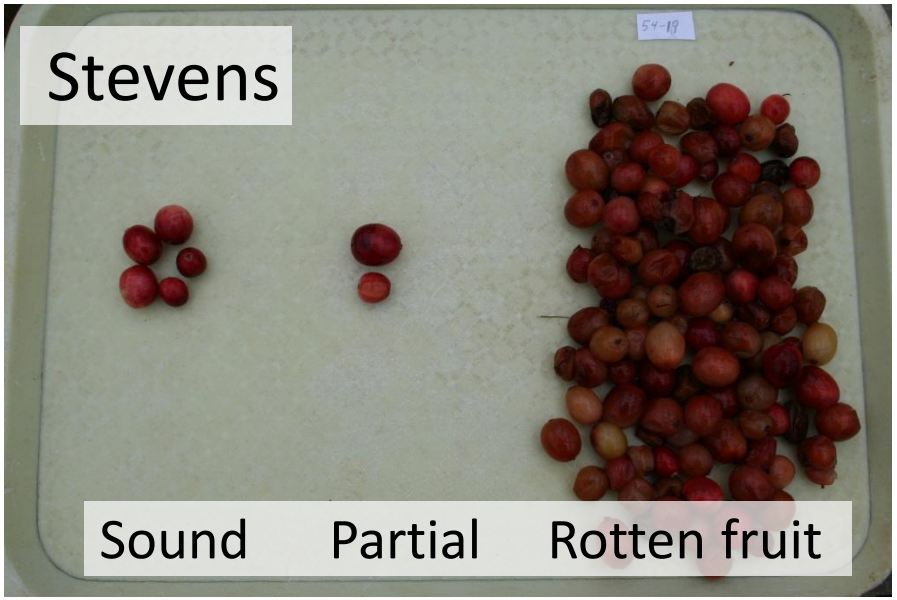

3-5 years to establish maturity

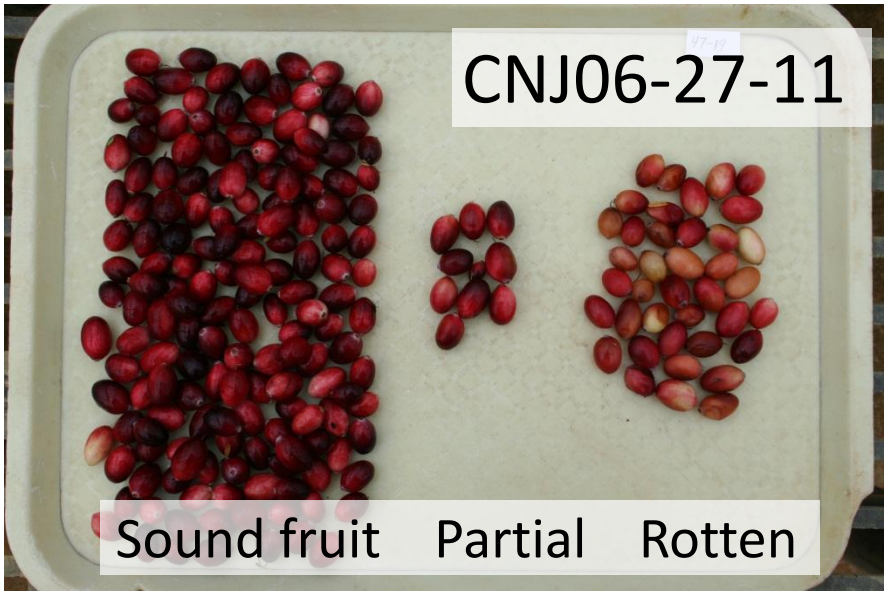
Heritability based on mid-parent - offspring



2012 Results - 1 ft^2 fruit samples from resistant progeny and susceptible controls, Oct. 2.







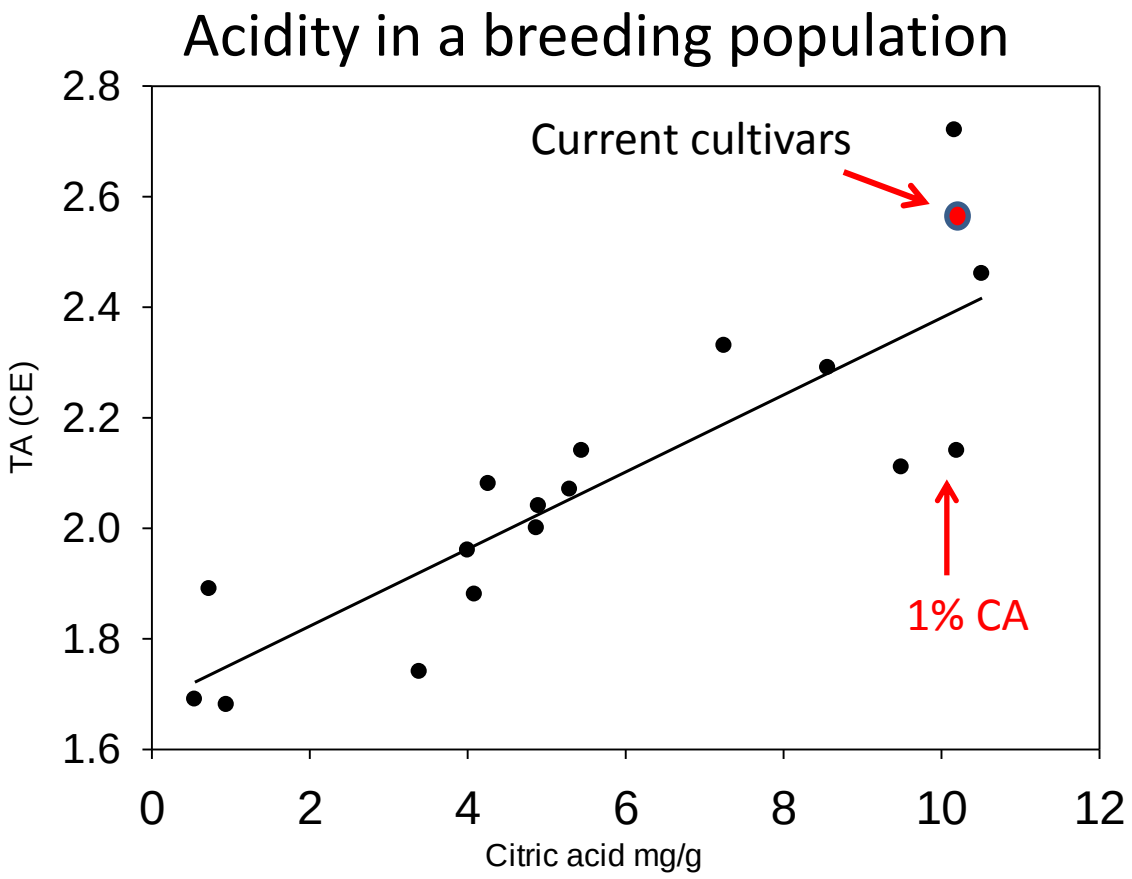
Cranberry TA – 2.5 CE

8-10 mg/g Citric Acid

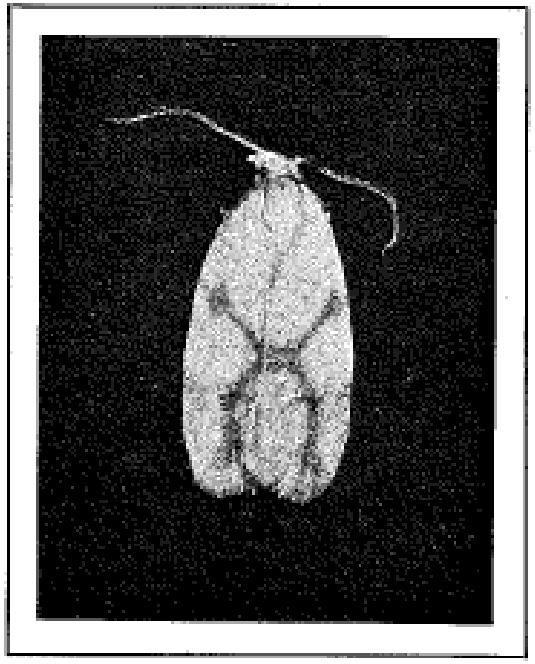
6-10 mg/g Malic Acid

Sugar/acid ratio

acids ↓ or sugars ↑



The sixty-seventh annual meeting of the American Cranberry Growers' Association was held at the Walt Whitman Hotel, Camden, N. J., January 30, 1937.



Five Times Natural Size

A New Cranberry Pest

False Yellowhead Fireworm, *Sparganothis sulfureana* (Clem.)

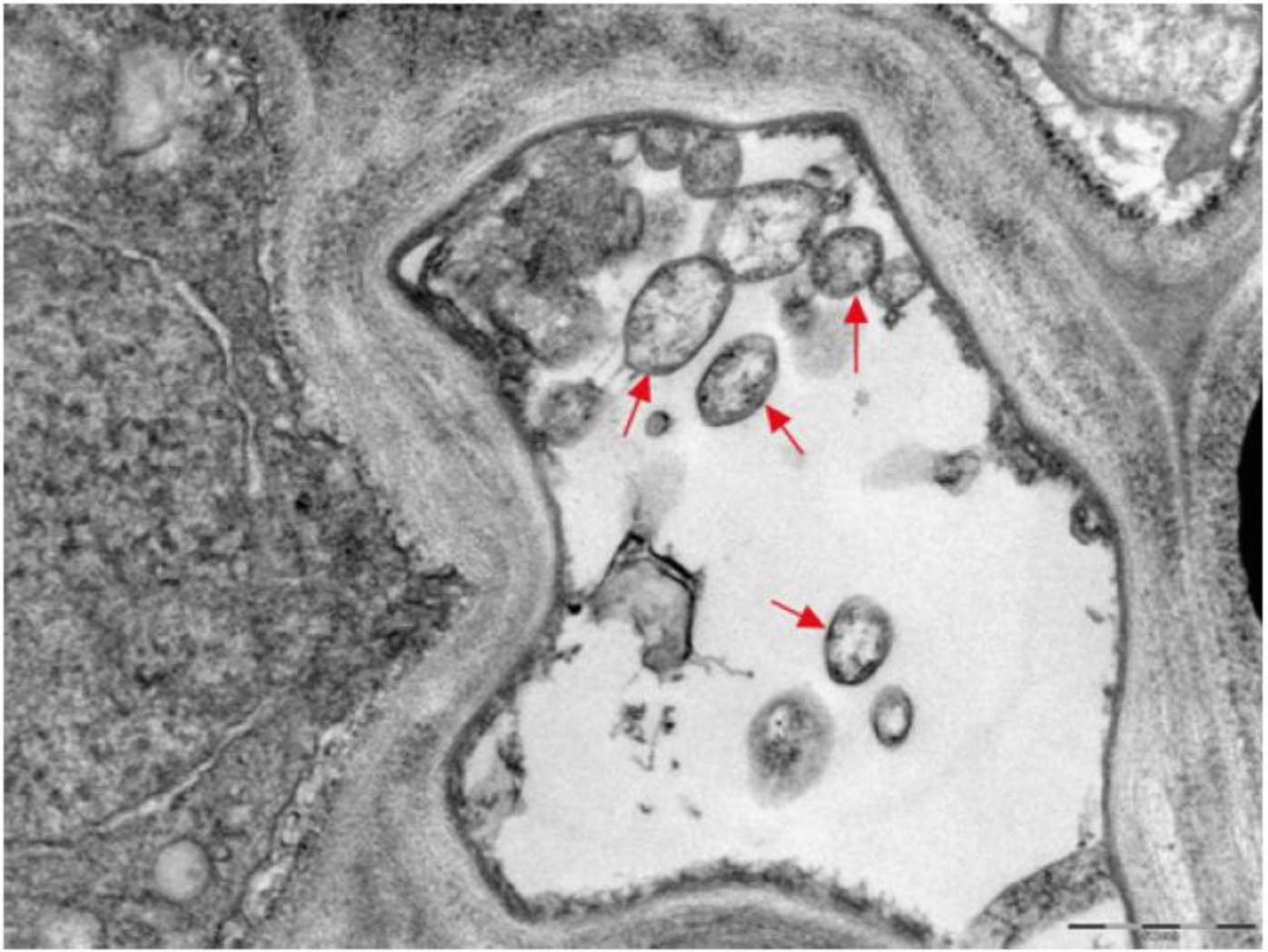
(Lighter Part is Yellow and the Dark Cross is Brown)

Blunt-nosed leafhopper

Scleroracus vaccinii

New subgroup 16SrIII-Yphytoplasmas associated with false-blossom diseased cranberry (*Vaccinium macrocarpon*) plants and with known and potential insect vectors in New Jersey

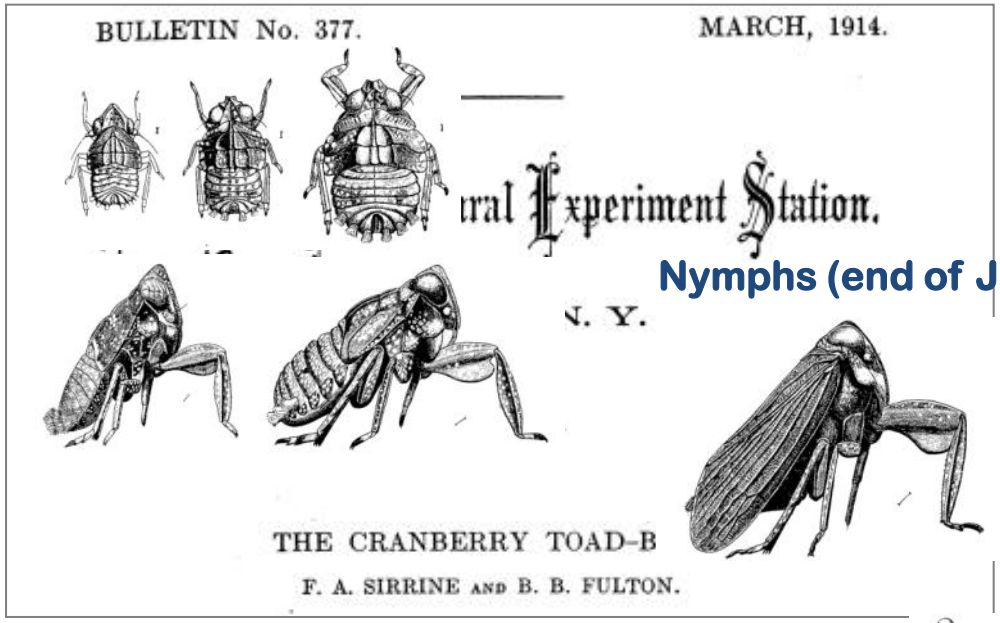
Lee et al. 2014 Eur. J. Plant Pathol.



Jaroslava Přibylová et al. 2014

Figure 2. Phytoplasma-like particles (red arrows) in a leaf midrib phloem cell of the diseased *Rhododendron* plant (*bar* = 500 nm).

Toad bug –
first found in NJ in 2013


BULLETIN No. 377. MARCH, 1914.

ural Experiment Station.

N. Y.

THE CRANBERRY TOAD-B

F. A. SIRRINE AND B. B. FULTON.

Nymphs (end of June-August)

Adults (August-October)

Eggs (September-October)

- *Phylloscelis atra* (Dictyopharidae). Described 1914
- Feeds only on cranberries.
- Single generation a year.
- Overwinters as eggs.

Pre-bloom | Bloom | Post-bloom | Harvest

Global warming

Chilling hrs.

- Union of Concerned Scientists?

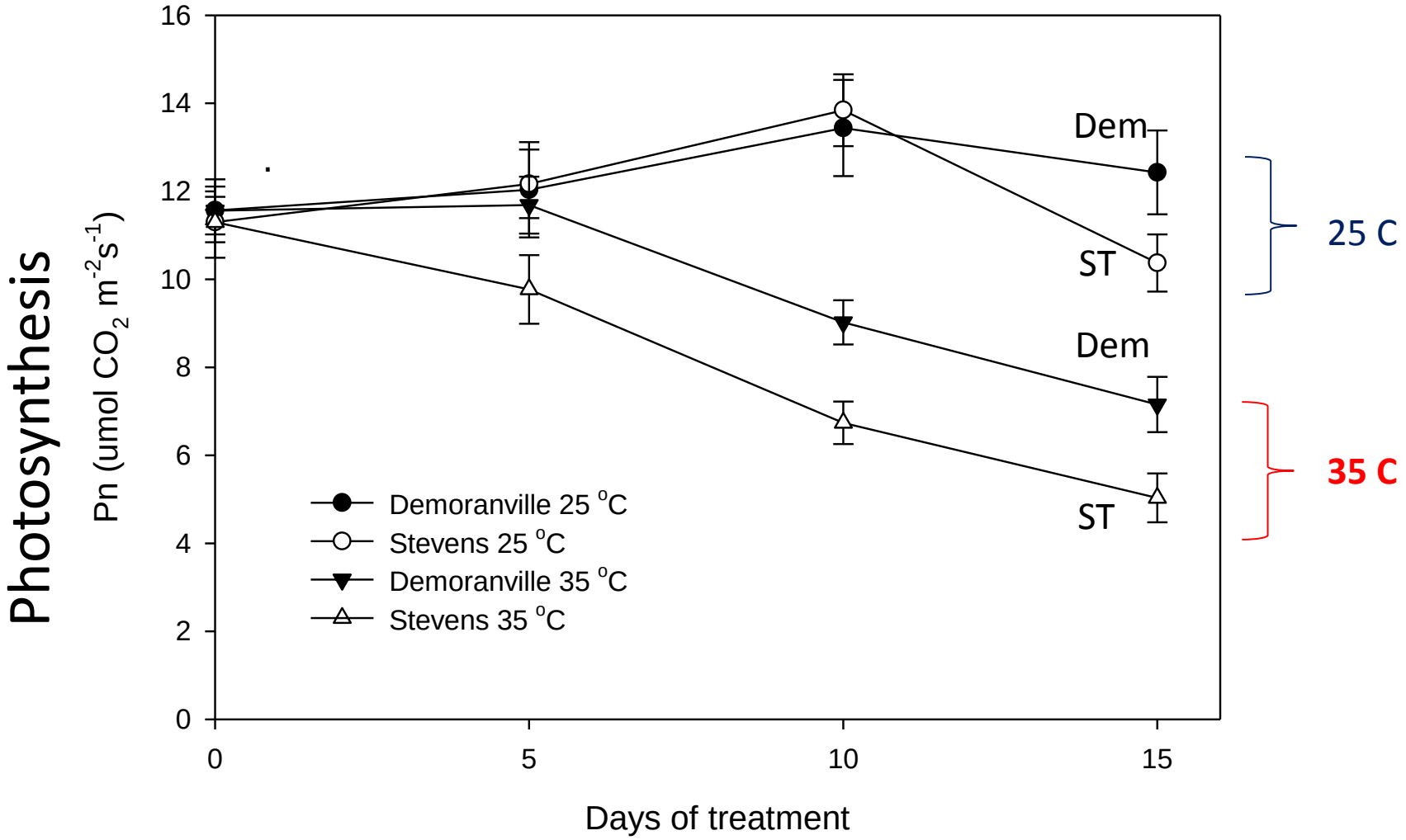
Heat Stress

- days over 90 °F expected to increase
- fruit rot pressure
- scald

Cranberry cultivar tolerance to heat stress

Demoranville® (selected in the 1990's)

Stevens (selected in the 1940's)



Unpublished data Huang and Xu

City Point, WI

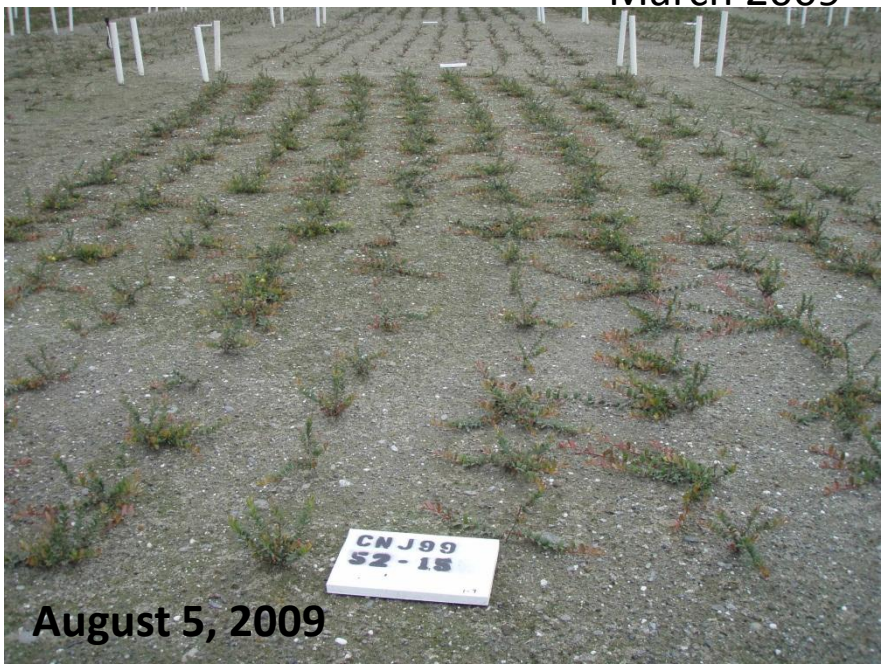
Planted

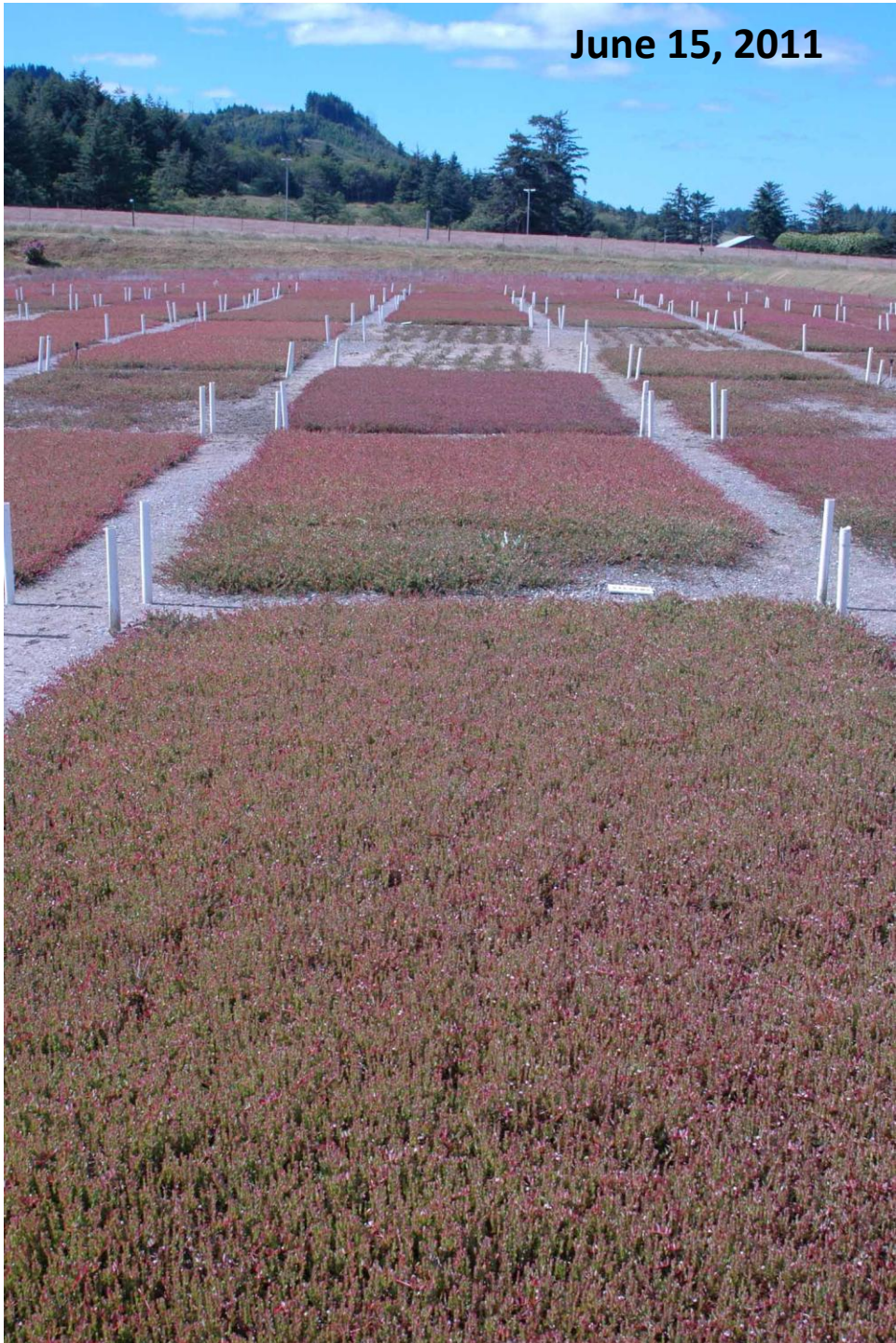
1st rep – 1999

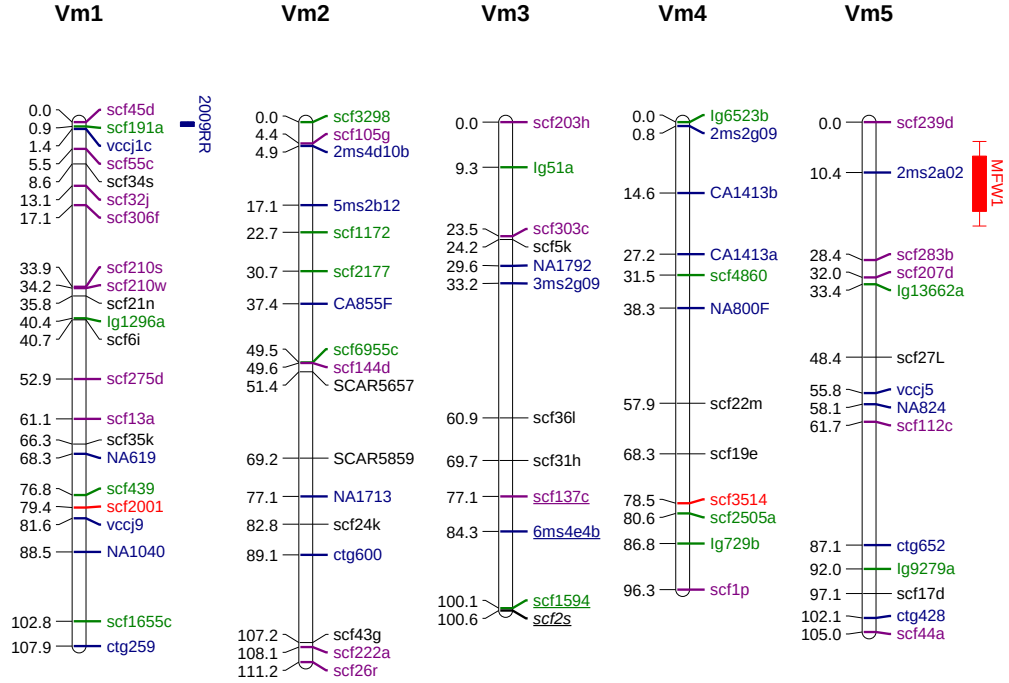
2nd rep – 2000

Bandon, OR

planted in March 2009



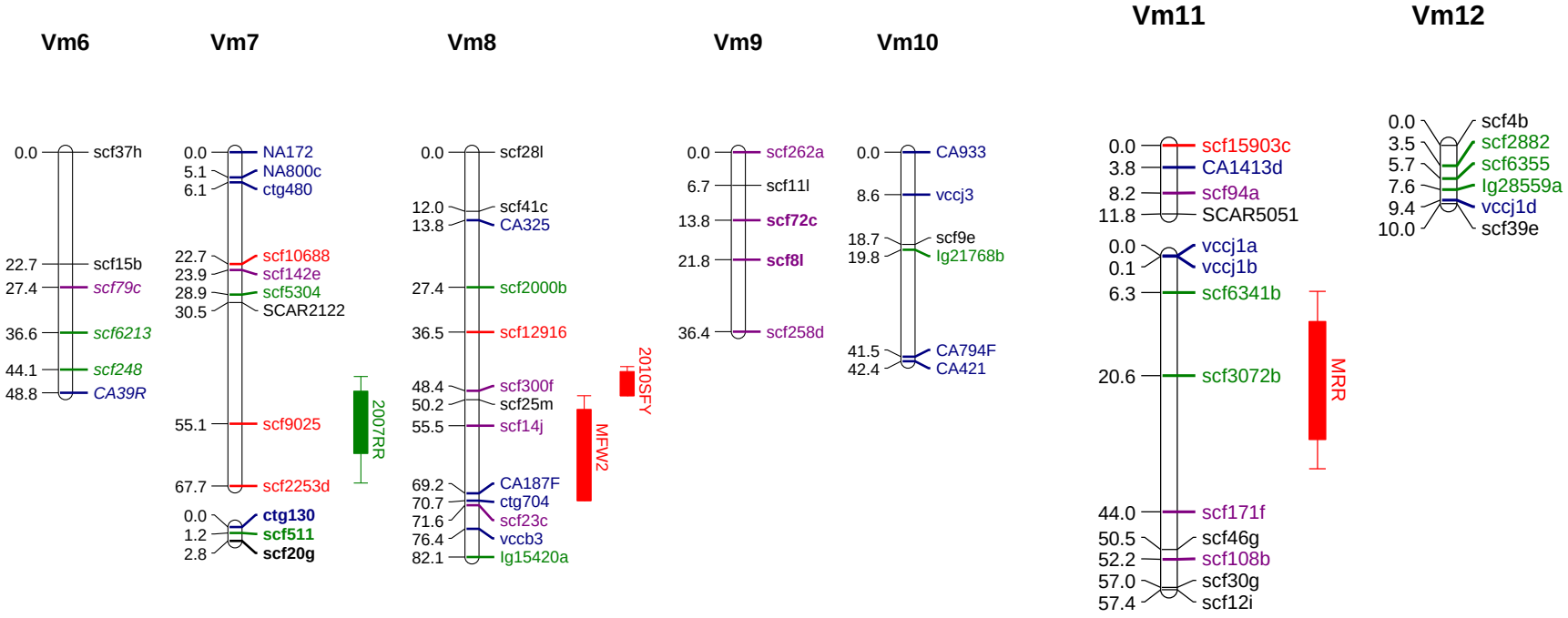


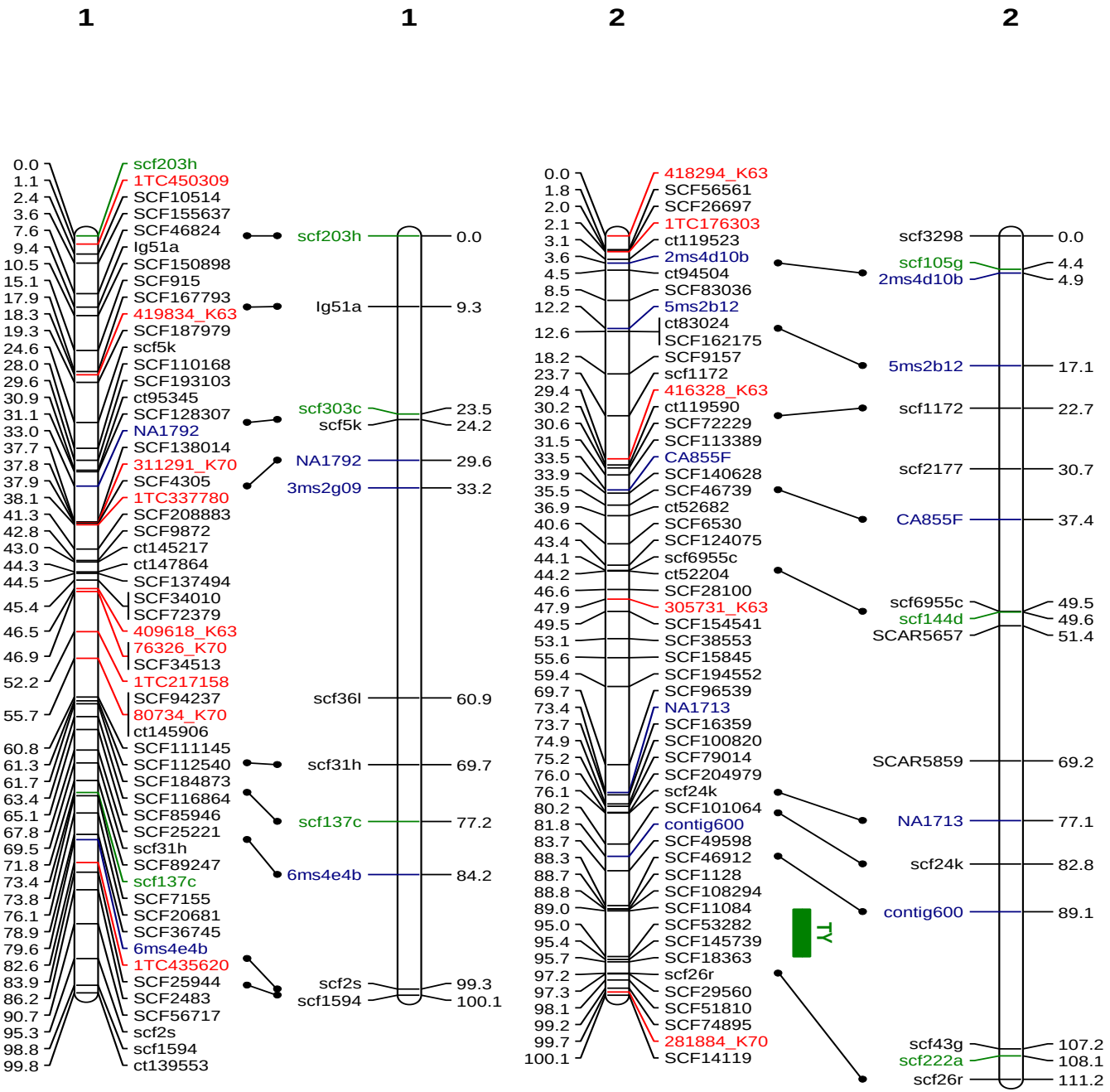


genome size of about 570 Mbp

- SSRs
- SCARs
- ESTs

SOLiD mate-paired
Illumina
Blueberry ESTs

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1
2
2
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3.6 SCF155637
7.6 SCF46824
9.4 lg51a
10.5 SCF150898
15.1 SCF915
17.9 SCF167793
18.3 419834_K63
19.3 SCF187979
24.6 scf5k
28.0 SCF110168
29.6 SCF193103
30.9 ct95345
31.1 SCF128307
33.0 NA1792
37.7 SCF138014
37.8 311291_K70
37.9 SCF4305
38.1 1TC337780
41.3 SCF208883
42.8 SCF9872
43.0 ct145217
44.3 ct147864
44.5 SCF137494
45.4 SCF34010
SCF72379
46.5 409618_K63
46.9 76326_K70
SCF34513
52.2 1TC217158
55.7 SCF94237
80734_K70
ct145906
60.8 SCF111145
61.3 SCF112540
61.7 SCF184873
63.4 SCF116864
65.1 SCF85946
67.8 SCF25221
69.5 scf31h
71.8 SCF89247
73.4 scf137c
73.8 SCF7155
76.1 SCF20681
78.9 SCF36745
79.6 6ms4e4b
82.6 1TC435620
83.9 SCF25944
86.2 SCF2483
90.7 SCF56717
95.3 scf2s
98.8 scf1594
99.8 ct139553
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lg51a 9.3
scf303c 23.5
scf5k 24.2
NA1792 29.6
3ms2g09 33.2
scf36l 60.9
scf31h 69.7
scf137c 77.2
6ms4e4b 84.2
scf2s 99.3
scf1594 100.1
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1.8 SCF56561
2.0 SCF26697
2.1 1TC176303
3.1 ct119523
3.6 2ms4d10b
4.5 ct94504
8.5 SCF83036
12.2 5ms2b12
12.6 ct83024
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18.2 SCF9157
23.7 scf1172
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30.6 SCF72229
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33.5 CA855F
33.9 SCF140628
35.5 SCF46739
36.9 ct52682
40.6 SCF6530
43.4 SCF124075
44.1 scf6955c
44.2 ct52204
46.6 SCF28100
47.9 305731_K63
49.5 SCF154541
53.1 SCF38553
55.6 SCF15845
59.4 SCF194552
69.7 SCF96539
73.4 NA1713
73.7 SCF16359
74.9 SCF100820
75.2 SCF79014
76.0 SCF204979
76.1 scf24k
80.2 SCF101064
81.8 contig600
83.7 SCF49598
88.3 SCF46912
88.7 SCF1128
88.8 SCF108294
89.0 SCF11084
95.0 SCF53282
95.4 SCF145739
95.7 SCF18363
97.2 scf26r
97.3 SCF29560
98.1 SCF51810
99.2 SCF74895
99.7 281884_K70
100.1 SCF14119
TY
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5ms2b12 17.1
scf1172 22.7
scf2177 30.7
CA855F 37.4
scf6955c 49.5
scf144d 49.6
SCAR5657 51.4
SCAR5859 69.2
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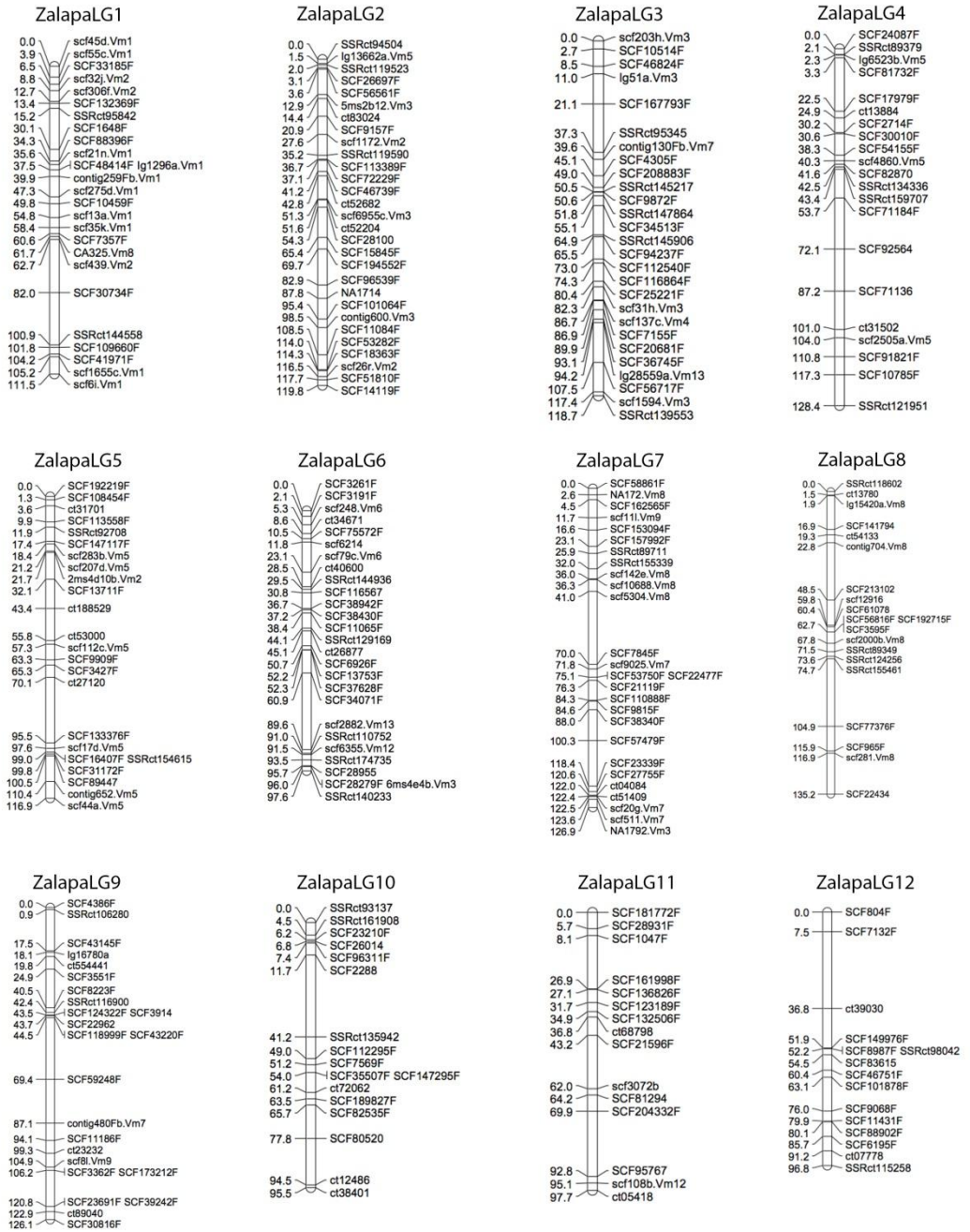
Crimson Queen x Mullica Queen



SSR Genetic Map - Zalapa et al. (2014)

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V. macrocarpon