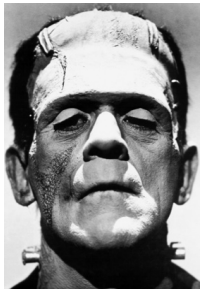
# GMO Fruit Crops



Richard Heerema
Extension Pecan & Pistachio Specialist

# Radiation-Induced Mutations ("GMOs"?)

- Some important older fruit varieties:
  - 'Stella' cherry (Canada, 1968)– self fertile flowers
  - 'Star Ruby' grapefruit (USA, 1970)– nearly seedless
  - 'Rio Red' grapefruit (USA, 1984)– deeper red fruit and juice

- Some recently released fruit varieties:
  - 'Nero' clementine (Spain, 2006)– earlier fruit ripening
  - 'Clemenverd' clementine (Spain, 2010)– delayed fruit maturation
  - 'Aldamla' cherry (Turkey, 2014)– compact growth habit
  - 'Burak' cherry (Turkey, 2014)– high yields, large fruit

Source: https://mvd.iaea.org/

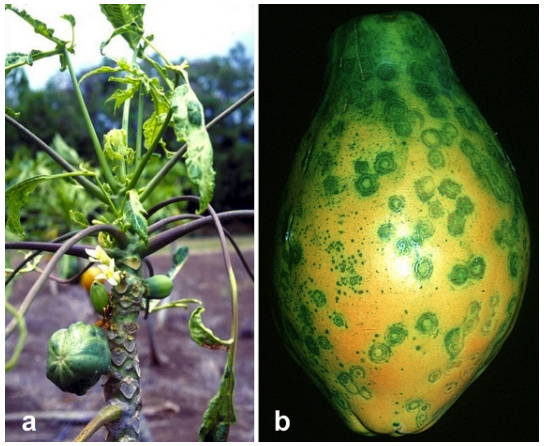
http://www.starkbros.com/products/fruit-trees/cherry-trees/stella-sweet-cherry

http://aggiehorticulture.tamu.edu/citrus/cultivars/rired.htm

# Papaya Ringspot Virus (PRSV)

- Affects papaya and cucurbits.
- Causes leaves to yellow and small fruit. Eventually kills the papaya tree.
- Aphid vectored.
- Devastated the papaya industry in the Puna area of Hawaii beginning in 1992.

An abandoned virus-infected papaya field.




Symptoms on tree and fruit.

http://www.apsnet.org/edcenter/intropp/lessons/viruses/Pages/PapayaRingspotvirus.aspx

# ‘SunUp’ and ‘Rainbow’ Papayas

- Developed by Dr. Dennis Gonsalves (Cornell University) and introduced in 1998.
- “Pathogen-derived resistance”-- the coat protein gene of a mild mutant of a PRSV strain
  - ‘SunUp’ was a transgenic line of ‘Sunset’.
  - ‘SunUp’ X ‘Kapoho’ → ‘Rainbow’ (yellow flesh).
- Makes up more than 75% of Hawaiian papaya acreage (2013).

Replanting with ‘Rainbow’

http://www.apsnet.org/publications/apsnetfeatures/Pages/PapayaHawaiianRainbow.aspx


http://www.ctahr.hawaii.edu/see d/images/sunup_mod.jpg

# Plum Pox Virus

- Causes Sharka disease in stone fruit
- Spread by aphids and infected budwood.
- Causes deformed fruits, fruit drop, leaf chlorosis, and tree decline.
- First discovered in US (PA) in 1999– eradicated
- Discovered in Canada in 2000– not eradicated.
- Discovered again in the US (MI and NY) in 2006– eradicated again.

http://www.ars.usda.gov/is/br/plumpox/

# ‘HoneySweet’ Plum

- Developed at USDA-ARS Appalachian Fruit Research Station.
- Resistant to Plum Pox Virus (PPV).
- Gene silencing or RNA interference (RNAi).
- Gene for PPV virus coat protein inserted into plant genome .
- By 2009 had been approved by APHIS, FDA, and EPA.
- No commercial production in US as of 2015.

http://www.ars.usda.gov/is/br/plumpox/

# Grapple® Brand Apple


**Ingredients:** Apples, natural and artificial flavor

**Kosher Information:** At this time, Grāpple® brand apples are not certified Kosher.

Not Transgenic!

http://www.grapplefruits.com

# Arctic® Apples


Arctic® Granny


Arctic® Golden

- Arctic®
  - Developed by Okanogan Specialty Fruits (Summerland, B.C.)
  - Silenced genes for biosynthesis of polyphenol oxidase which is responsible for fruit flesh browning.
  - Arctic® Golden and Arctic® Granny have been approved by US and Canadian regulatory agencies in early 2015.
  - Arctic® Gala and Fuji are also in the works.

Arctic APPLES

http://www.arcticapples.com/arctic-apples-r/arctic-apples-varieties/

# FasTrack Breeding

http://www.ars.usda.gov/SP2UserFiles/Program/305/Oct2010GrapeWorkshop/Scorza%20-%20GRAPE%20RESEARCH%20WORKSHOP%20(3)%2010-26-10.pdf

- Original genetic stock (with desired trait) transformed with poplar FT gene.
- Causes seedlings to bloom early and continuously.
  - Speeds up breeding process by many, many years!
- Crosses made until a high quality tree with desired trait is achieved.
- Finally, non-FT (and non transgenic) types are selected for release.

# Transgenic Trap Crops

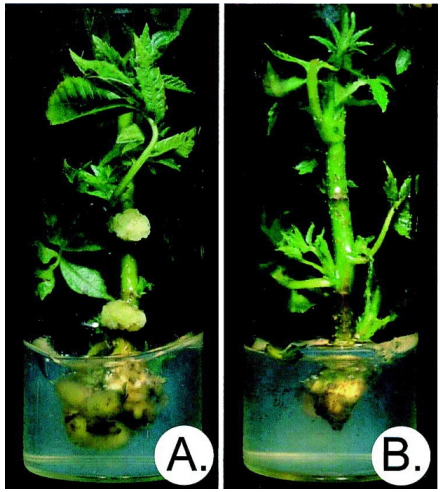
- John Driver (Dry Creek Labs) and Abhaya Dandekar (UCD)– patented.
- Interplanting the Bt-expressing apple trees in non-transgenic walnut orchard.
- Codling Moth damage to walnuts almost completely controlled without pesticide applications.

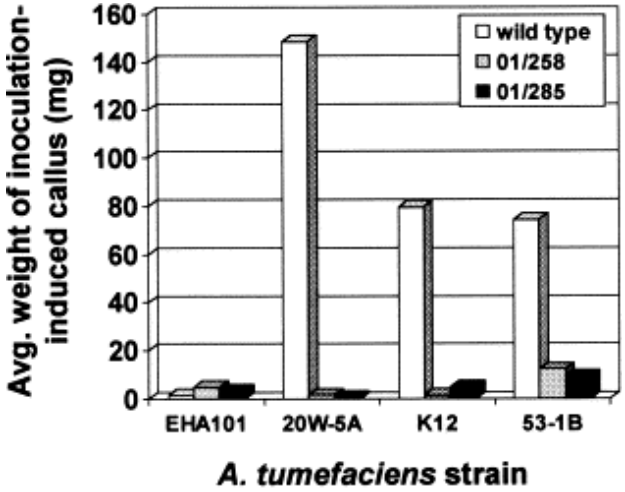

http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7412.html

http://www.cabi.org/agbiotechnet/news/3872
http://californiaagriculture.ucanr.org/landingpage.cfm?articleid=ca.v058n02p96

# Transgenic Rootstocks

Crown gall in walnut.




Escobar MA, Leslie CA, McGranahan GH, Dandekar AM. 2002. Silencing crown gall disease in walnut (*Juglans regia* L.). Plant Sci 163:591–7.

# Citrus greening (HLB)

Growing Produce

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‹ California Technology Summit Targeting Early Detection Of Deadly Citrus Disease Slated

New Citrus Greening Nutritional Mix Enters The Market ›

November 25, 2015

## Scientists Find Success Fighting Citrus Greening With GMOs

Posted By: Paul Rusnak | Email Print Facebook 128 Google LinkedIn 6 Twitter

UF/IFAS researchers say they have developed genetically modified citrus trees that show enhanced resistance to greening, and have the potential to resist canker and black spot, too.

Jude Grosser, a professor of plant cell genetics at the UF/IFAS Citrus Research and Education Center in Lake Alfred, and Manjul Dutt, a research assistant scientist, used a gene isolated from *Arabidopsis thaliana*, a member of the mustard family, to create the new trees. Their experiment resulted in trees that exhibited enhanced resistance to greening, reduced disease severity, and even several trees that remained disease-free after 36 months of planting in a field with a high number of diseased trees.

Grosser and Dutt's research team used sweet orange cultivars Hamlin and Valencia and created plants that defend themselves against pathogens utilizing a process called systemic acquired resistance (SAR). SAR provides protection against a broad spectrum of microorganisms and is associated with the production of anti-pathogen proteins.

Disease resistance to HLB in this study was evaluated in two ways:

- First, in a greenhouse study conducted with Southern Gardens Citrus in Clewiston, several hundred trees (clones from several independent transgenic plant lines) were exposed continuously for two years to free-flying, greening-positive psyllids. Trees were routinely pruned and fertilized to stimulate new leaf production. These trees were evaluated every six months for two years for the presence of greening. The insects were also randomly evaluated during this study for the presence of the greening bacterium. Approximately 45% of the trees expressing the Arabidopsis gene tested negative for greening. In three of the transgenic lines, the greening bacterium was not detected at all. Control trees tested positive for the presence of greening within six months and remained positive for the entire duration of the study.
- In the second concurrent study, selected transgenic trees and controls were cloned, grown, and planted in fields with a 90% percent HLB infection rate. These trees were similarly evaluated every six months for three years for the presence of the greening bacterium. In this study, one transgenic line remained greening-free for the duration of the study, except for the 24-month sampling period when it tested positive. A second line tested positive at the 30-month sampling period while a third line tested positive at 30 months, but was greening-free at 36 months. Neither of these lines declined in health, and both showed continued growth with periodic flushes.



*A set of transgenic citrus trees with the Arabidopsis thaliana NPR1 gene construct on trial in South Florida. Photo courtesy of UF/IFAS*

http://www.growingproduce.com/citrus/insect-disease-update/scientists-find-success-fighting-citrus-greening-with-gmos/

"Transgenic trees exhibited reduced disease severity and a few lines remained disease-free even after 36 months of planting in a high-disease pressure field site." Dutt et al. (2015)

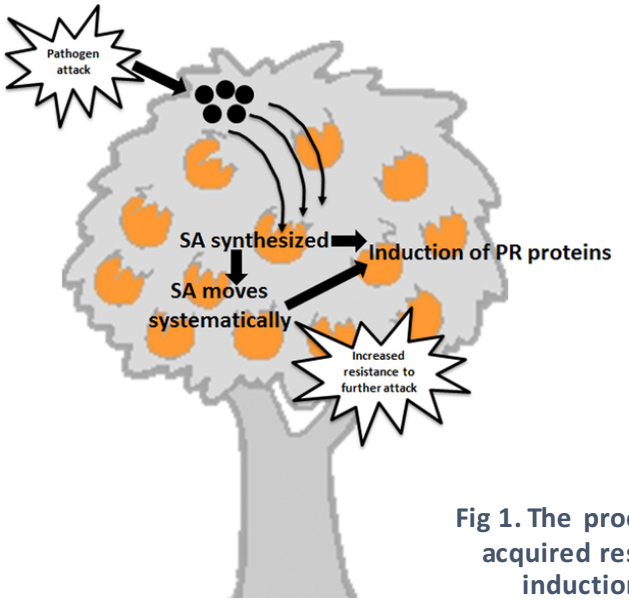


**Fig 1. The process of systemic acquired resistance (SAR) induction in citrus.**

Dutt M, Barthe G, Irey M, Grosser J (2015) Transgenic Citrus Expressing an Arabidopsis NPR1 Gene Exhibit Enhanced Resistance against Huanglongbing (HLB; Citrus Greening). PLoS ONE 10(9): e0137134. doi:10.1371/journal.pone.0137134
http://journals.plos.org/plosone/article?id=info:doi/10.1371/journal.pone.0137134

PLOS ONE

# “Ornacitrus”

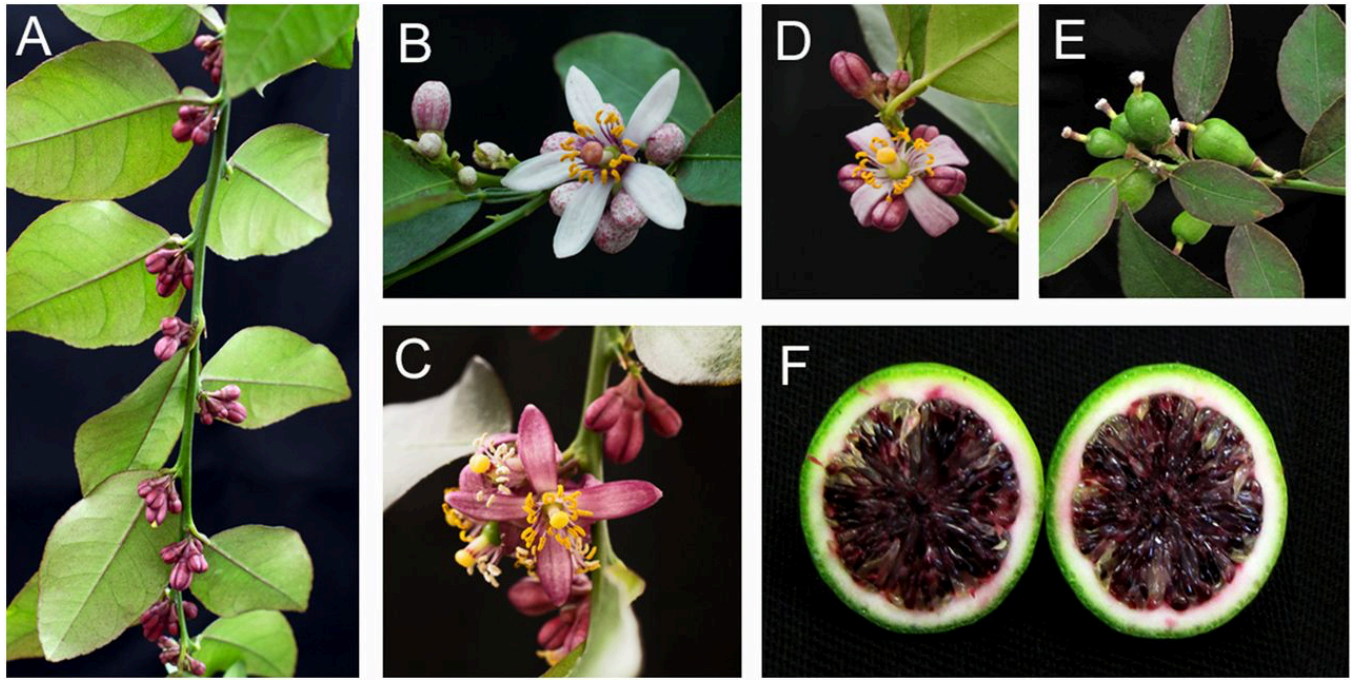


Fig. 2.
(A) Flower clusters on a VvmybA1 overexpressing ‘Mexican’ lime transgenic line. (B and C) Close-up of flowers on two independent VvmybA1 overexpressing lines. (D) Close-up of flowers on a Ruby overexpressing line. (E) A fruit cluster on a VvmybA1 overexpressing ‘Mexican’ lime line. (F) A cross-section of a fruit from a VvmybA1 overexpressing ‘Mexican’ lime line demonstrating the production of anthocyanin in the pulp.

Fig. 3.
Cross-sections of a transgenic Ruby overexpressing ‘Mexican’ lime fruit with a control nontransgenic fruit for comparison.

Dutt et al., 2016.

# Questions?