**Botany and Physiology of the Pistachio Tree**

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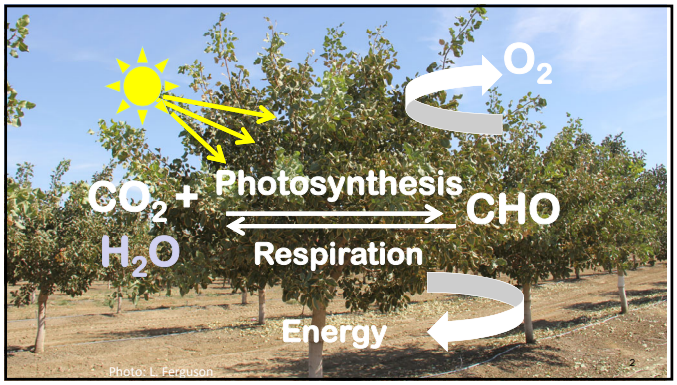



## Botany

- Order: Sapindales
- Family: Anacardiaceae
- Genus: Pistacia
- Species: vera


## Botany

- Temperate deciduous tree
- *Pistacia* species native to areas from 40° to 70° latitude
- *P. vera* is from Western Asia and Asia Minor
- Introduced to California in early 20th century
  - Didn't become economically important until later 20th century

## Botany

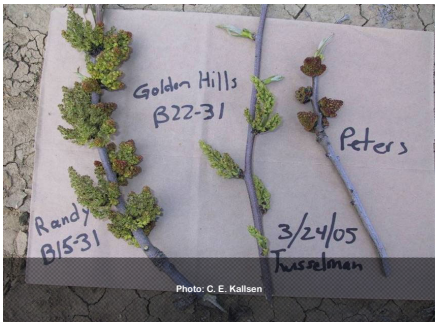
- 25-35 feet (7.6-10.6 meters) in height
- Apically dominant
- Long juvenility
- Bears crop on one-year-old wood
- Alternate bearing scion

## Dioecious

- Definition: Separate houses
- Bloom overlap critical

Male Female

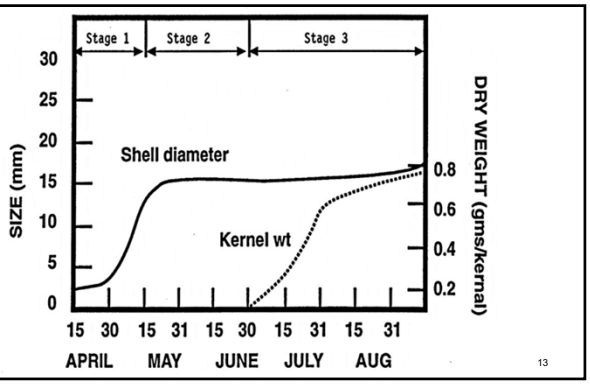
Photos: Louise Ferguson

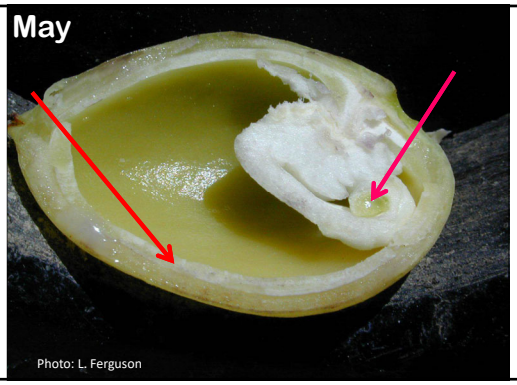




**Pistachio Flowers**

- 100-200 flowers
  <4% set, resulting in an average of 14 fruit
  5-30% blanks
- Apically dominant
  - Most nuts are at the terminus (8% of total flowers)
- Fruit is a drupe
- Capable of parthenocarpy


Stage 1
Stage 2
Stage 3
30
25
20
15
10
5
0
SIZE (mm)
Shell diameter
Kernel wt
0.8
0.6
0.4
0.2
DRY WEIGHT (gms/kernal)
15 30 15 31 15 30 15 31 15 31
APRIL MAY JUNE JULY AUG
13


May
Photo: L. Ferguson
14


June
Photo: L. Ferguson
15

Photo: L. Ferguson

16


Photo: L. Ferguson

17


Photo: L. Ferguson

18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## Growing Degree Day Requirements

High heat needed in summer

| | Kerman | Golden Hills | Lost Hills |
|---|---|---|---|
| Stage I | 756 | 705 | 751 |
| Stage II | 2583 | 2830 | 3157 |
| Stage III | Starts at 1000, ends at 2111 | Starts at 931, ends at 1904 | Starts at 982, ends at 2021 |

## Temperature Requirements

- Cool winters with temperatures in the 40s
  - No hard freezes
  - No late or early freezing temperatures
- Chill hours
  - Kerman: > 750 hours @ < 32-45 $^{o}$ F (0 - 7.2 $^{o}$ C)
  - Peters: > 900 hours @ < 32-45 $^{o}$ F (0 - 7.2 $^{o}$ C)

## Dormancy

- Dormancy: when growth does not occur in living plants
  - Endodormancy: when growth does not occur due to conditions within the plant
  - Ecodormancy: when growth does not occur due to conditions external to the plant

## Does it matter which model is used?

### What is known about chill models

| Information from controlled experiments | Chilling Hours | Utah | Utah+ | Dynamic Model | |
|---|---|---|---|---|---|
| Depends on temperature | + | + | + | + | |
| Daily temperature cycle | + | + | + | + | |
| Weighted temperatures | - | + | + | + | |
| Continuous weights | - | - | - | + | |
| Warm temperatures - | - | + | - | + | |
| Moderate temperatures + | - | - | - | + | |
| Two-phase process | - | - | - | + | |

Luedeling et al. Erwerbsobstbau (submitted).

## Temperature Requirements

- Cool winters with temperatures in the 40s
  - No hard freezes
  - No late or early freezing temperatures
- Chill hours
  - Kerman: > 750 hours @ < 42-45 $^{o}$ F (5.8 - 7.2 $^{o}$ C)
  - Peters: > 900 hours @ < 42-45 $^{o}$ F (5.8 - 7.2 $^{o}$ C)
- Chill portions
  - Kerman > 59
  - Peters > 69

## Modelling Yield

- Last year's yield strongest predictor of current year's yield
- Temperatures > 65$^{o}$ F (18.3$^{o}$ C) during dormancy period (Nov 15 to Feb 15) negatively correlated with current season's yield
  - Each hour in excess of this temperature resulted in a loss of 13.1 lbs/ac (14.7 kg/ha)
- Models should not be taken literally
- But it shows that there's more involved than just chill

## Critical Temperatures

- Critical cold temperatures largely unknown
  - Rootstock more sensitive than the scion
  - 11 nights between 4$^{o}$ and 11$^{o}$ F (-15.5 to -12$^{o}$ C)in 1990
    - *P. integerrima*: 41% mortality
    - *P. atlantica*: 0% mortality
    - *P. atlantica x P. integerrima*: 0% mortality

## Winter Juvenile Tree Dieback (formerly called frost damage)

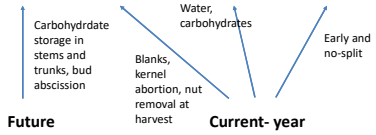
- There is no research-backed data, much of what we know is based off observations from Craig Kallsen and Blake Sanden
- Associated with rootstocks that have *P. integerrima* parentage (PGI or UCBI, either seedling or clonal
- Associated with high vigor trees in the fall, and usually but not always associated with frost events
- Risk factors:
  - Trees that are vigorous going into the fall
  - Wet soils
  - Sodium affected soils (due to poor water movement from dispersed soils)


## Drought Tolerance

- Phreatophytes
  - Can exploit deep reservoirs of water
- Leaves adapted to maintain turgor in arid conditions
  - Thick cuticle
  - Xerophytic palisade mesophyll adaptation
  - More abaxial stomata than adaxial
  - Stomatal conductance higher on abaxial side
  - Stomata located near leaf veins

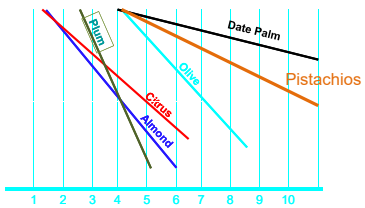
## Drought Tolerance

- Components of yield =
  #clusters x #nuts/cluster x nut weight x nut quality





## Salt Tolerance

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## Salt Tolerance

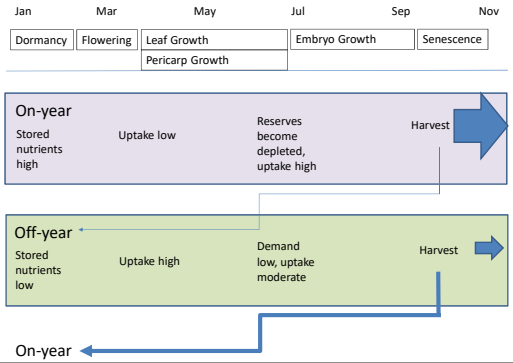
- Specific ion damage
- Osmotic effects

## Salt Tolerance

- Greenhouse study conducted by L. Ferguson (2001) shows that osmotic effects are greater than specific ion effects
  - *P. integerrima* rootstocks less tolerant of salt-affected rootzones than *P. atlantica* or the hybrids.
- Established trees can be irrigated with water up to 8 dS/m (rootzone salinity of 11.4 dS/m) without affecting yield (B. Sanden, 2004)
- Salt tolerance of establishing orchards is lower (5 dS/m) (B. Sanden, 2014)

## Pistachio Nutrient uptake

- Pistachios take up nutrients at a rate reflecting demand
- No uptake during dormancy
- Little uptake between harvest and leaf senescence
- Fruit shows strong demand for nutrients
  - High uptake during nut fill
- Higher uptake during on years than off
  - Accumulation mostly in fruit in on-year trees, perennial tissues in off years

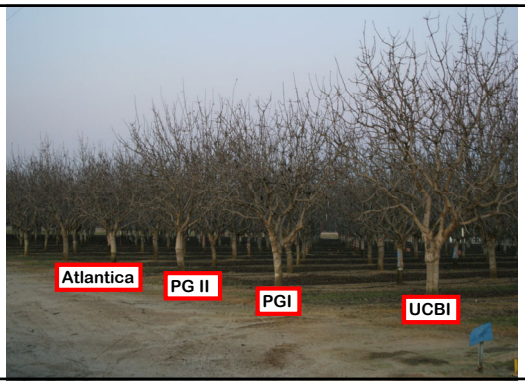


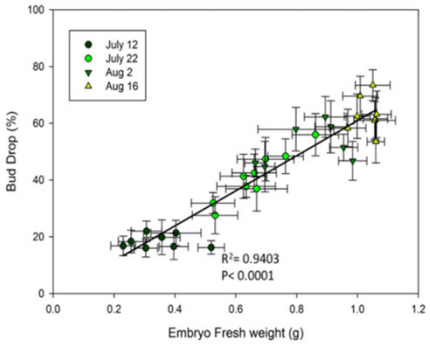

## Physiological Issues

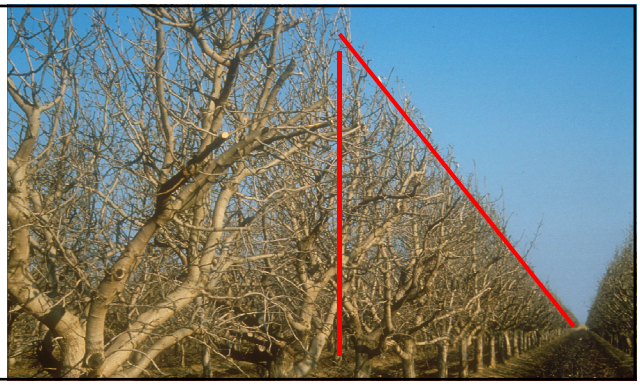
- Alternate bearing
- Non-splits
- Blank nuts

## Alternate bearing is dependent on variety and rootstock (slide corrected on 11/2/2020)

- Lost hills: I = 0.2
- Golden Hills: I = 0.3
- Kerman: I = 0.5
- Modern, more vigorous rootstocks have reduced alternate bearing
  - This may be that vigorous trees are larger and have more leaf area (and produce more carbohydrates)
  - It may be due to differing abilities to scavenge nutrients
- Not all trees in an orchard are uniformly 'on' or 'off'


Atlantica
PG II
PGI
UCBI


July 12
July 22
Aug 2
Aug 16
Bud Drop (%)
Embryo Fresh weight (g)
R²= 0.9403
P< 0.0001
0
20
40
60
80
100
0.0
0.2
0.4
0.6
0.8
1.0
1.2



## 7 Year Yield Response
## *P. atlantica* rootstock

- **Hedged and Topped**
- 1985: 0.8 kg/tree
- 1986: 12.7 kg/tree ON
- 1987: 6.4 kg/tree
- 1988: 11.8/kg/tree ON
- 1989: 5.1/kg/tree
- 1990: 12.2/kg/tree ON
- 1991: 11.6/kg/tree

- **60.6/kg/tree cumulative**

- **Control**
- 1985: 2.9 kg/tree OFF
- 1986: 22.1 kg/tree
- 1987: 1.6 kg/tree OFF
- 1988: 15.3/kg/tree
- 1989: 0.1/kg/tree OFF
- 1990: 16.7/kg/tree
- 1991: 1.4/kg/tree OFF

- **60.1/kg/tree cumulative**

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## Dusty conditions during bloom could affect blanking

- Pistachio flowers artificially pollinated with dust, or pollen contaminated with dust, had greater blank %
- NOT conducted in 'naturally' dusty conditions

| | % Fruit set | % nut drop | Blank % | % Splits |
|---|---|---|---|---|
| Control (bagged) | 3.6 | 46.4 | 83.3 | 0 |
| Pollen | 18.2 | 11.5 | 10.9 | 51.7 |
| 50% dust mix | 17 | 10.4 | 16.5 | 61.7 |
| 75% dust | 24.2 | 15.4 | 42.6 | 30.9 |
| 94% dust | 11.5 | 17 | 39.3 | 31.6 |
| Dust | 3.3 | 0 | 80 | 10 |
| 50% herbicide contaminated dust | 5.2 | 100 | N/A | N/A |

Adapted from Zheng et al. (2019)

# Thank you!

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