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Harvest Preparation

1. Irrigation
2. Navel Orange Worm (*Amyelois transitella*)
3. Determining when to harvest

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1. Irrigation

- Shell splitting and individual nut weight are most sensitive to water stress (Goldhamer, 2003)
- Prevent water deficits July through harvest
  - maintain adequate soil moisture to maximize shell splitting; while keeping rows dry for harvesters

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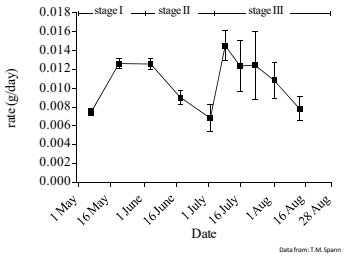
Nut dry weight accumulation



Data from: T.M. Spann

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2. Navel Orange Worm

Prevent NOW infestation of early splits

- 3rd generation of NOW coincides with early splits (early- to mid-August)
- In early splits: shells split before the hulls dehisce, and the hull also splits, exposing the kernel
- Infestation of even 1% nuts can result in Aflatoxin levels above max. allowable

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2. Navel Orange Worm

- During the **last two weeks of July**: monitor for early splits.
- Consider making a treatment if there are >2 early split nuts per 100 nuts, and if navel orangeworm eggs are consistently found.
- Choose the pesticide with the greatest IPM value
- Beware of Preharvest Interval (PHI) and plan your harvest accordingly
- www.ipm.ucdavis.edu

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3. Determining when to harvest

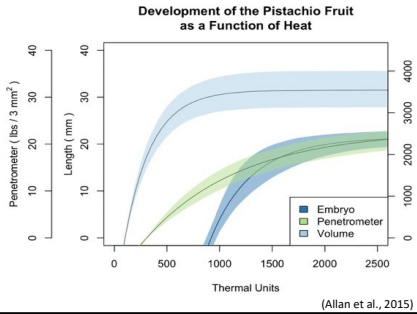
- Hulls turns from green to ivory to rose pink blush
- Shell turns from translucent to opaque
- Lack or color change usually indicates a blank/aborted nut
- Color change/maturation usually linked with shell splitting
- At full maturation, the nut ejects when hull is pressed with fingers
- Fat and sugar content: **Increase**
- Kernel moisture, respiration rate, total protein content: **Decrease**

Maturity Indices

- Harvesting indices in pistachios have been studies in Europe and Australia but we lack information in California, particularly on new cultivars
- Hull color change (Green to yellow): Ripening
- Broken lines on the skin: Feathering
- Hull becoming rough: Broken and finally, becomes shriveled
- Kernel volume and nut density increase quickly >> exerting physical force from inside > splitting the shell open

Nut growth is a function of heat, or physiological time

- Growth stages can differ between different locations by a few weeks.
- Using local historical and current temperatures in the Gompertz model the pistachio nut growth stages, including split, can be predicted.



(Allan et al., 2015)

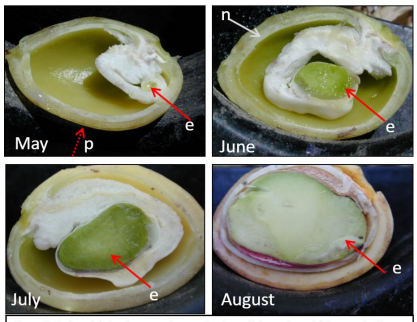


Figure 1. Embryo (e) development does not begin until the pericarp (p) has reached its maximum size. Although endocarp (n) hardening is initiated prior to embryo development, these two processes do occur simultaneously (Allen et al., 2014).

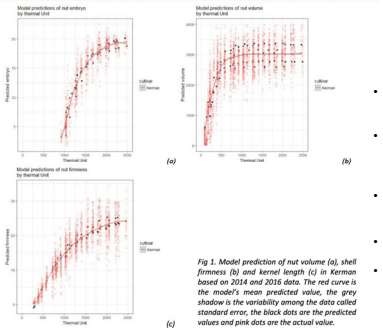


Fig 1. Model prediction of nut volume (a), shell firmness (b) and kernel length (c) in Kerman based on 2014 and 2016 data. The red curve is the model's mean predicted value, the grey shadow is the variability among the data called standard error, the black dots are the predicted values and pink dots are the actual value.

Zhang et al., 2016
(Louise Ferguson Lab, UC Davis)

- Modeled nut growth parameters to predict each phenological stage in nut growth.
- Using this model, the three nut growth stages can be predicted based on heat unit accumulation by applying the prediction curve.
- The time of fruit set is a biofix at which thermal unit (TU) accumulation is equal to zero.
- Shell hardening didn't reach the peak value even by harvest.
- A web application was developed where you can plug in local temperature data to get optimum harvest date.

Determining when to harvest…

- Hull separates cleanly from shell
- Formation of abscission layer
  - – Nuts separate from rachis with a gentle shake
- Optimal harvest time: 2-3 weeks around full maturity period
- Ethephon, a compound that hastens maturity and reduces variability in maturity in many crops: **Is ineffective in pistachios!** (Crane et al., 1981)

Determining when to harvest

- Another factor is: Availability of harvesting equipment, harvesting crews, transporters and processors
- Kerman is still the major cultivar in California, while other cultivars are gaining acreage
- Essentially a one month window, stretched a little by new cvs.
- Harvest scheduling an important factor: cultivar selection, diversifying

New UC Cultivars: harvest timings v. Kerman

Trial site	Cultivar	Mean Harvest Readiness Date
Twisselman	Kerman	Sep 17
	Golden Hills	Aug 29
	Lost Hills	Sep 2
Buttonwillow	Kerman	Sep 12
	Golden Hills	Aug 30
	Gumdrop	Aug 20
Madera	Kerman	Sep 17
	Golden Hills	Sep 5
	Lost Hills	Sep 5

(Adapted from Kallsen and Parfitt, Cal. Ag., 2020)

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Harvesting: basic principle

- Nuts removed by shaking or knocking (depending on tree age)
- Harvested either on a catch-frame or on tarps
- Nuts considered fragile (high moisture content, open shells)
  - So contamination can occur if they touch the ground
  - Aflatoxin: produced by a fungi, *Aspergillus spp.*

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Harvesting Young Trees (6 years or younger)

- Spread tarps 5 feet beyond canopy
- Knock trunk with padded mallet or pole near clusters
- Remove large debris and dump tarps into bins
- Bins hold ~1000 lb

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Harvesting Mature Trees

- Two separate, self-propelled units
  - One unit contains a shaker head to clamp on tree trunk and shake
  - The other joins the shaker unit to form a continuous collection surface
  - Bin harvesting: Once shaken off, nuts are conveyed over a belt to the bins, blowing off debris on the way via separator fan/blower
  - Bulk harvesting: Nuts are conveyed directly to a bulk hauler that moves along within the row


Photo: TM Spann


Photo by: G. Thurner, CSU Fresno


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Photo from: American Pistachio Growers

Photo from: www.orchardtech.com

Many large operations do bulk harvesting instead of bin harvesting where the nuts are carried up directly to a bulk hauler.
More efficient on a large scale.

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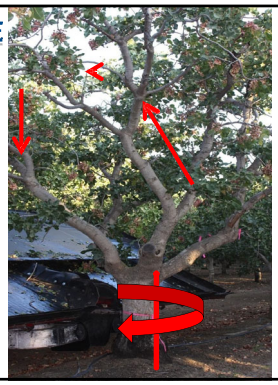
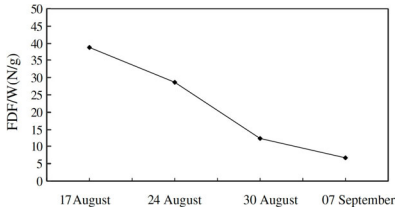
Harvest efficiency

- Harvest Efficiency is a function of:
  - Tree age
  - Trunk circumference
  - Canopy dimensions

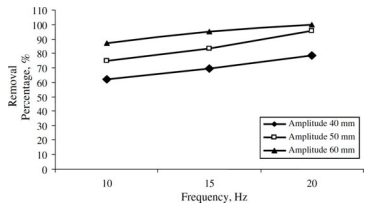


Relationship of Fruit detachment Force with Maturity stage



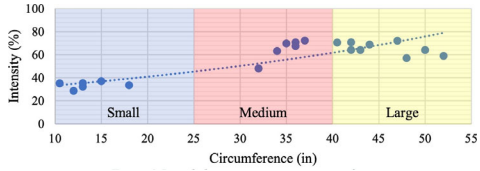
Polat et al., 2007)

Shaking frequency and amplitude on nut removal



Ehsani et al. (2019): Improving harvesting efficiency

- Newer harvesting systems can create different shaking patterns with varying intensity vs. time
- Determining best shaking frequency and pattern is challenging:
  - Is a function of canopy size, trunk circumference, branch configuration etc.
- Shaking intensity: a function of normalized power X time of shake in seconds

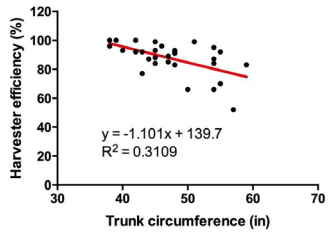


New training systems: Lampinen et al.

- Conventional vs modified central leader vs unpruned
- Very early to draw inferences but this is something to watch closely
- Modified tree architecture will have a great impact on harvesting procedures as we know it today

Photo: TM Spann

Harvester Efficiency



Data from: L. Ferguson

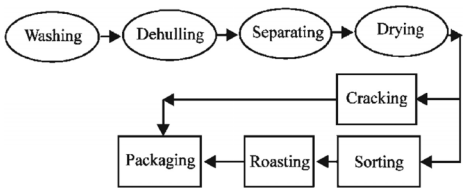
Transport

- Shell staining increases during postharvest transport and storage (particularly if hull damage occurred at harvest)
  - ⇧ temp + ⇧ storage time = ⇧ staining
  - Temp in trailers can increase up to 1.1° F/hr
  - Good quality, intact hulls can be help up to 48 hrs
  - Poor quality, damaged/tattered hulls, show damage after:
    - 8 hrs @ 104°F; 24 hrs @ 86°F; 40 hrs @ 77°F

Tips for transport

- Keep the bins in shade
- Bulk trailers: greater potential for ⬆ in nut temp. (Esp. in front-bottom)
- If transported in bins, at least 5% of vertical surface should be vented
- Trailer at highway speed ➡ Air Ventilation
- If delay is 2 days or longer:
  - Storage at 32^{O}F; Airflow- 0.1 cu ft/min/lb and <70% RH

Processing procedures



Polat et al., 2007

Pistachios delivered in tared flatbed or bulk trailer are weighed and tagged for delivery fresh weight

⇩

Temperature within the load is measured

⇩

Nuts dumped and conveyed over an air leg to remove debris

⇩

20-pound (9-kilogram) unhulled sample is separated for separate processing and grading

⇩

Hulls are removed from nuts with an abrasive peeler

Hulls are removed as soon as possible after delivery to avoid staining by trapped moisture

Blank nuts are separated by float tank and separately dried and stored

⇩

Filled split and non-split nuts are dried to 12 - 13% moisture in a high temperature dryer

⇩

Transferred to grain bins for final drying (to 4-6% moisture)

⇩

Stored at ambient temperature with forced air flow

⇩

Splits separated from non-splits by needle picking drum

⇩

Non-splits are shelled or split mechanically

⇩

Split nuts sorted by electronic color reflectance sorter

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Split nuts are hand graded to remove defects, debris

⇩

Split nuts are salted

⇩

Split nuts are roasted

⇩

Split nuts are packaged and stored or shipped

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USDA Inspection

- Percent by weight
- Split inshell
  - Stain, insects, defects
- Split shelling stock
  - Insects, defects
- Closed shell
  - Blanks, insects, defects

Grading

- Grading trays
- 19 categories
- Sample run through mesh first

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Grower Resources

- UC Davis Fruit & Nut Research & Information Center
  - Fruitsandnuts.ucdavis.edu
- UC Davis Postharvest Technology Center
  - Postharvest.ucdavis.edu
- UCCE Mechanical Harvesting of Pistachios
  - Ucanr.edu/sites/mechpistachio

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Thanks!

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