How Potential Changes in Climate Could Affect Pistachio Production

Katherine Jarvis-Shean
Orchard Systems Advisor
Sacramento, Solano & Yolo Counties

Outline of Talk

• Introduction to winter chill
• Central Valley winters in the future?
• What warmer winters could mean for pistachio production.

Three Take Aways

• We will experience more “low chill” winters in the future.
• Kerman will not be appropriate for many parts of the San Joaquin Valley in 30-40 years.
• Dormancy breaking chemicals may help in the short term. New low chill varieties will be necessary long term.
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Why is winter chill important?

April 4th 2015
Kerman Peters
Chill models work very differently

Chill Hours
- 1 hour between 32-45°F = 1 chill hour

Chill Portions (Dynamic Model)
- Different temps have dif. 'chill value.'
  - Max hours at 43-47°F.
  - No chill value at 32°F and 54°F.
- Expands the range of temps considered effective for chill accumulation.

Warm temperatures can subtract from chill accumulation.

Winter Heat Delays Budbreak, Decreases Yield

Budbreak in the spring is preceded by a big up-swing in starch in the tree. (Tixier et al., 2019)

If conditions are warm in the winter, trees adjust their starch-making system to keep starch low & sugars stable mid-winter. But then it takes more heat than normal years to achieve high starch pre-budbreak. (Sperling et al., 2019)

Warm temperatures in winter (>65°F) had more influence on yield than cold temperatures (<45°F). (Kallsen, 2017)

2013-2014: Hours vs. Portions

Chill Hours:
Average winter.

Chill Portions:
Unusually Warm.
How to count and use chill portions

Tracking chill portions on FNRIC
1st: Copy-paste hourly temperature data into this column.
Data must be hourly, and in Celsius. If your data is in Fahrenheit, use Tab 3 to convert from Fahrenheit to Celsius.

2nd: Highlight Row 12, Columns C-L. Copy this section for all temperatures, down to the last hour.
Outline of Talk

- Introduction to winter chill
- **Central Valley winters in the future?**
- What warmer winters could mean for pistachio production.

Have California winters been getting warmer?
Yes. Especially in the last 40 years.

- Lots of variability year-to-year
- Different weather networks & datasets differ on exact change trends.
- All records show trend of increased Max & Min Temps from 1970-2014

Wang et al. (2017)

Have Central Valley winters been getting warmer?
Yes.

Wang et al. (2017)
Winters have also been getting less foggy

Time fogged in

Change in temperature from 1985–1994 to 2060–2069
- 16 different global “general circulation models”
- 5 different ways to scale down to regional level
- Sac Valley: ↑ 3.1°F (1.7°C)
- San Joaquin Valley: ↑ 3.2°F (1.8°C)

Climate models project winters will keep getting warmer.
Climate models project winters will continue to vary a lot from year to year.

- Winter-to-Winter variability will be 2x the expected shift in temperature.
- So, we'll still experience some cold winters, and winters that we now consider average.
- But we'll also experience more "low chill" winters AND lower chill winters than before.

Chill Projections 90% of years, for Mid, End of Century

<table>
<thead>
<tr>
<th>Turn of the Century</th>
<th>Mid 21st Century</th>
<th>End 21st Century</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sac Valley</td>
<td>70 (-14%)</td>
<td>49 (-30%)</td>
</tr>
<tr>
<td>N. San Joaquin</td>
<td>71 (-14%)</td>
<td>51 (-28%)</td>
</tr>
<tr>
<td>S. San Joaquin</td>
<td>64 (-20%)</td>
<td>42 (-34%)</td>
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- Introduction to winter chill
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Chill requirements of current cultivars

<table>
<thead>
<tr>
<th>Crop (CA Cv.'s)</th>
<th>Chill Portions Requ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerman*</td>
<td>54-58</td>
</tr>
<tr>
<td>Peters*</td>
<td>60-65</td>
</tr>
<tr>
<td>Lost Hills</td>
<td></td>
</tr>
<tr>
<td>Golden Hills</td>
<td></td>
</tr>
<tr>
<td>Gumdrop</td>
<td></td>
</tr>
<tr>
<td>Randy</td>
<td></td>
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*Based on how chill & harvest, 2014

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Luedeling et al. (2009)

Dormancy breaking products could help with 10-20% chill decrease

- Kaolin clay, calium carbonate in winter decreases bud, shoot heat (Doll, Culumber)
- Dormant/Horticultural Oil can increase budbreak, make it earlier (Beede, Ferguson)
- Early data shows ethylene, GA₃ may have similar results to oil (Brar, 2018)
- Hydrogen cyanamide can increase budbreak, make earlier. Not reg’d (Beede, Ferguson, Intl)
- New research on the physiology of dormancy may help generate other solutions (Dr. Z)
Chill Projections 90% of years, for Mid, End of Century

<table>
<thead>
<tr>
<th>Type</th>
<th>Cultivar</th>
<th>Chill Hours (&gt;7°C)</th>
<th>Country of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Male</td>
<td>206 (36 CP)</td>
<td>Tunisia</td>
</tr>
<tr>
<td>Female</td>
<td>Uzun</td>
<td>600</td>
<td>Turkey</td>
</tr>
<tr>
<td>Female</td>
<td>Halebi</td>
<td>650</td>
<td>Turkey</td>
</tr>
<tr>
<td>Female</td>
<td>Siirt</td>
<td>700</td>
<td>Turkey</td>
</tr>
<tr>
<td>Female</td>
<td>Kale-Ghuchi</td>
<td>775</td>
<td>Iran</td>
</tr>
<tr>
<td>Female</td>
<td>Kerman</td>
<td>800</td>
<td>California</td>
</tr>
<tr>
<td>Male</td>
<td>Male-1</td>
<td>500</td>
<td>Turkey</td>
</tr>
<tr>
<td>Male</td>
<td>Male-2</td>
<td>750</td>
<td>Turkey</td>
</tr>
<tr>
<td>Male</td>
<td>Peters</td>
<td>900</td>
<td>California</td>
</tr>
</tbody>
</table>

Lower chill varieties will be necessary production in many areas after mid-Century

More Heat \(\rightarrow\) More NOW generations

Pathak et al., 2020
Three Take Aways

- We will experience more “low chill” winters in the future.
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Thank you! Questions?