What to Consider: Almond Varieties

December 6, 2016
What to Consider:
Almond Varieties

Bob Curtis, Almond Board of California
(Moderator)

Tom Gradziel, UC Davis

Harbinder Maan, M.B.A., Almond Board of California

Dani Lightle, University of California
Bob Curtis, Almond Board of California
Almond Varieties for Future Plantings

Opportunities -and Risks

Tom Gradziel
Dept. of Plant Sciences
UC Davis
More than 100 varieties in California

Milo Wood, USDA Bull. #1282, 1925
Almond Acreage by Variety

All but a few (green) California varieties are progeny of Mission by Nonpareil cross.
Red box estimates the amount of variability currently utilized within California varieties. Violet box estimates the amount of variability accessible within heirloom cultivars and land races. Yellow box estimates of genetic diversity available within closely related species.
Nonpareil vs. Other Varieties
(Average Annual Price (USD/lb) & NP Production)

- NPS 23/25 ($)
- CA SSR 27/30 AOL ($)
- NP Price Advantage (%)
- NP Production (%)


$5.00 $4.50 $4.00 $3.50 $3.00 $2.50 $2.00 $1.50 $1.00 $0.50 $0.00
0.0% 10.0% 20.0% 30.0% 40.0% 50.0% 60.0%

Courtesy N. T. Ryan
Nonpareil Almond

- High nutrient
- Large Kernel size
- Self-fruitful

- Disease resistance
- Pest resistance
- High flavor
New germplasm = New traits = New solutions

Plus some old problems
Multiple opportunities for crop improvement

...and failure

Anna Karenina principle: Happy families varieties are all alike; every unhappy family variety is unhappy in its own way.
Breeding: Transfer of self-compatibility to good kernel size/quality

Maximum yield at about 1 gram kernel mass
Self-fruitfulness = **Self-compatibility** + **Self-pollination**

**Self-compatibility** is controlled by a Single gene and so easily transferred

**Self-pollination** is much more complicated
Alternate bearing
Orchard (life) yield
## Kernel Quality

<table>
<thead>
<tr>
<th>Performance</th>
<th>Nonpareil</th>
<th>Sweetheart</th>
<th>Marcona</th>
<th>Heritable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid (%)</td>
<td>38.8 a</td>
<td>43.4 b</td>
<td>42.6 b</td>
<td>No</td>
</tr>
<tr>
<td>Oleic Acid (%)</td>
<td>66.8 a</td>
<td>73.0 b</td>
<td>72.2 b</td>
<td>No</td>
</tr>
<tr>
<td>Self-compatability (%)</td>
<td>3.1 a</td>
<td>28.7 b</td>
<td>3.8 a</td>
<td>Yes</td>
</tr>
<tr>
<td>Aflatoxin</td>
<td>83.7 a</td>
<td>18.1 b</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>NOW (%)</td>
<td>79.5 c</td>
<td>4.1 b</td>
<td>0 a</td>
<td>No</td>
</tr>
<tr>
<td>Hull Rot (%)</td>
<td>97.3 c</td>
<td>23.1 a</td>
<td>82.4 b</td>
<td>Partial</td>
</tr>
</tbody>
</table>

- **Hull Resist. Hull rot (NOW)**
- **Seedcoat Resist. NOW Aspergillus Aflatoxin**
- **Shell seal Resist. NOW (Aspergillus)**
- **Kernel meat Resist. Aflatoxin**
## Kernel allergens & aflatoxin

<table>
<thead>
<tr>
<th>Origin</th>
<th>P. ELISA</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. argentea</em> (bitter seed)</td>
<td>0.61</td>
</tr>
<tr>
<td><em>P. argentea</em> (BC1)</td>
<td>0.26</td>
</tr>
<tr>
<td>(Misson × <em>P. argentea</em>) F2</td>
<td>0.44</td>
</tr>
<tr>
<td><em>P. baigasi</em> (bitter seed)</td>
<td>0.59</td>
</tr>
<tr>
<td><em>P. persica × P. davidiana</em> (bitter seed)</td>
<td>0.45</td>
</tr>
<tr>
<td><em>P. fenulifera</em> (F2)</td>
<td>1.53</td>
</tr>
<tr>
<td><em>P. fenulifera</em> (F2)</td>
<td>1.66</td>
</tr>
<tr>
<td><em>P. fenulifera</em> (BC1)</td>
<td>2.18</td>
</tr>
<tr>
<td>(Misson × <em>P. fenulifera</em>) BC1 × Sonora</td>
<td>0.61</td>
</tr>
<tr>
<td>(Misson × <em>P. fenulifera</em>) BC1 × Sonora</td>
<td>1.56</td>
</tr>
<tr>
<td>(Misson × <em>P. fenulifera</em>) BC1 × Sonora</td>
<td>0.95</td>
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<tr>
<td>(Misson × <em>P. fenulifera</em>) BC1 × Sonora</td>
<td>0.92</td>
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<tr>
<td>(Misson × <em>P. fenulifera</em>) BC1 × Sonora</td>
<td>0.7</td>
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<tr>
<td><em>P. mira</em> (bitter seed)</td>
<td>0.53</td>
</tr>
<tr>
<td>Peach (<em>P. persica</em>) (bitter seed)</td>
<td>0.51</td>
</tr>
<tr>
<td>Almond × <em>P. persica</em></td>
<td>0.39</td>
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<tr>
<td>Almond × <em>P. persica</em></td>
<td>0.66</td>
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<tr>
<td>Almond × <em>P. persica</em></td>
<td>0.75</td>
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<tr>
<td>(Nonparell × <em>P. persica</em>) F2 (bitter seed)</td>
<td>0.56</td>
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<tr>
<td>(P. persica) BC4</td>
<td>0.63</td>
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<tr>
<td><em>P. tomentosa</em> (bitter seed)</td>
<td>0.7</td>
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<tr>
<td><em>P. webbii</em> (bitter seed)</td>
<td>0.88</td>
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<tr>
<td><em>P. webbii</em> (F2)</td>
<td>0.64</td>
</tr>
<tr>
<td><em>P. webbii</em> (bitter seed)</td>
<td>0.51</td>
</tr>
<tr>
<td>*P. webbii × (Nonparell × <em>P. persica</em>) BC1</td>
<td>0.53</td>
</tr>
<tr>
<td><em>P. webbii</em> (BC1)</td>
<td>1.27</td>
</tr>
<tr>
<td><em>P. webbii</em> (BC1)</td>
<td>0.47</td>
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<tr>
<td><em>P. webbii</em> (BC1)</td>
<td>0.66</td>
</tr>
<tr>
<td><em>P. webbii</em> (BC1)</td>
<td>0.68</td>
</tr>
<tr>
<td><em>P. webbii</em> (BC1)</td>
<td>0.47</td>
</tr>
<tr>
<td><em>P. webbii</em> (F2BC1)</td>
<td>0.33</td>
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<tr>
<td><em>P. webbii</em> (BC1)</td>
<td>1.06</td>
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<tr>
<td>Almond × *P. webbii × <em>P. persica</em> (BC2)</td>
<td>0.42</td>
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<tr>
<td>Almond × *P. webbii × <em>P. persica</em> (BC3)</td>
<td>0.9</td>
</tr>
<tr>
<td><em>P. webbii</em> (BC4)</td>
<td>0.4</td>
</tr>
<tr>
<td>Almond × *P. webbii × <em>P. persica</em> (BC4)</td>
<td>1.93</td>
</tr>
<tr>
<td>Almond × *P. webbii × <em>P. persica</em> (BC4)</td>
<td>0.55</td>
</tr>
</tbody>
</table>

**Mascona**

<table>
<thead>
<tr>
<th></th>
<th>P. ELISA</th>
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<tbody>
<tr>
<td>Nonparell</td>
<td>1.02</td>
</tr>
<tr>
<td>Chipra</td>
<td>1.68</td>
</tr>
<tr>
<td>Kahl</td>
<td>1.22</td>
</tr>
<tr>
<td>Ternipino</td>
<td>1.56</td>
</tr>
</tbody>
</table>
Challenges of Climate Change

Almond is a highly adaptable species
Central Valley Regional Variety Trials

Regional Variety Trials:
Identify Problems before Widespread Plantings
“While a few of the California varieties, such as Nonpareil, IXL, and Ne Plus Ultra, have proved valuable, most of them are relatively worthless, and their dissemination and cultivation have resulted in much disappointment and loss” (Milo Wood, 1925)
‘where are almonds go on the grocery shelf is also important. Next, to provide context in terms of how almonds are used in snacking and an ingredient, Harbinder will review the US market as a case study’.

Thank you
Harbinder Maan, Almond Board of California
Category Usage – US Market

Harbinder Maan
Senior Manager, Global Trade Stewardship, Almond Board of California
Agenda

• Nielsen Sales Data – Key Almond Product Categories
• Why do consumers like almonds?
• Texture and flavor
• Summary
US Retail Sales

• Where do our Almonds go?
Nielsen Limitations: Scanner Data – Key Outlets Included

- Food: Kroger, Walmart
- Drug: Walgreens
- Club: BJ's
- Mass: Target
Total Almond Volume Summary (lbs) – US Retail Data – Nielsen, 2015

Note: Volume does not represent all US sales data but those outlets providing scanner data

All numbers are in pounds.
*Foods sold in the United States
## Category Performance: Estimated Pure Almond Volume

<table>
<thead>
<tr>
<th>Category</th>
<th>Est. Pure Almond Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2012</td>
</tr>
<tr>
<td>Total Snack Nuts &amp; Seeds</td>
<td>160.9</td>
</tr>
<tr>
<td>Milk Substitutes</td>
<td>14.5</td>
</tr>
<tr>
<td>Chocolate</td>
<td>24.0</td>
</tr>
<tr>
<td>Bars – Pure &amp; Mixed</td>
<td>15.9</td>
</tr>
<tr>
<td>Nut &amp; Seed Butters</td>
<td>5.8</td>
</tr>
<tr>
<td>RTE Cereal</td>
<td>7.8</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>10.3</td>
</tr>
<tr>
<td>Non-Chocolate Candy</td>
<td>1.5</td>
</tr>
<tr>
<td>Frozen Novelties</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>241</strong></td>
</tr>
</tbody>
</table>
Why do consumers like almonds

- US Consumer Awareness, Attitudes and Usage
• “Tastes great” was the most important attribute consumers considered when buying nuts (88% rated as very/somewhat important).
  - “Is satisfying” and “good as a snack” were the top secondary considerations (both at 82%), with many other attributes being very important in consumers’ decisions.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Very Important</th>
<th>Extremely Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tastes great</td>
<td>88%</td>
<td>30%</td>
</tr>
<tr>
<td>Is satisfying</td>
<td>82%</td>
<td>46%</td>
</tr>
<tr>
<td>Good as a snack</td>
<td>82%</td>
<td>46%</td>
</tr>
<tr>
<td>Perfect Snack for me</td>
<td>76%</td>
<td>39%</td>
</tr>
<tr>
<td>Healthy</td>
<td>75%</td>
<td>41%</td>
</tr>
<tr>
<td>Nutritious</td>
<td>74%</td>
<td>40%</td>
</tr>
<tr>
<td>Convenient/ easy to eat</td>
<td>74%</td>
<td>37%</td>
</tr>
<tr>
<td>High in protein</td>
<td>70%</td>
<td>36%</td>
</tr>
<tr>
<td>Heart healthy</td>
<td>69%</td>
<td>36%</td>
</tr>
<tr>
<td>Provides vital nutrients</td>
<td>67%</td>
<td>34%</td>
</tr>
<tr>
<td>Provides energy</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>Can be eaten “on the go”</td>
<td>66%</td>
<td>32%</td>
</tr>
<tr>
<td>Has a great crunchy texture</td>
<td>65%</td>
<td>36%</td>
</tr>
<tr>
<td>Fun to eat</td>
<td>63%</td>
<td>32%</td>
</tr>
<tr>
<td>A source of fiber</td>
<td>62%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Q15: For each the following statements, how important is each to you when deciding which type of nut to buy?
Awareness: Snack Association

- Almonds had the highest association with being a snack (30%) among US respondents, followed by peanuts (24%) and cashews (19%).
  - Pistachios (11%) was the only other nut to have an association as a snack above 10%.

Q2: Now, think for a moment about nuts as a snack (i.e., a food eaten between meals or instead of a meal), as a whole nut. When you think about eating whole nuts by themselves apart from a meal, what one type of nut FIRST comes to mind?
Almond Consumption: Frequency of Consumption by Form

- As an ingredient, almonds were most often consumed in energy/cereal bars, in breakfast cereals, and in chocolate.
- In terms of whole almonds, many forms were very popular, with blanched and in-shell being the least frequently consumed.

**Frequency of Almond Consumption**
% Selecting “Several times/month” or more often
(n=1,650)

<table>
<thead>
<tr>
<th>Almond as Ingredient</th>
<th>Whole Almonds</th>
</tr>
</thead>
<tbody>
<tr>
<td>In energy or cereal bars</td>
<td>51%</td>
</tr>
<tr>
<td>In breakfast cereals</td>
<td>50%</td>
</tr>
<tr>
<td>In chocolate</td>
<td>47%</td>
</tr>
<tr>
<td>In bakery items</td>
<td>38%</td>
</tr>
<tr>
<td>Almond milk</td>
<td>37%</td>
</tr>
<tr>
<td>Almond butter</td>
<td>26%</td>
</tr>
</tbody>
</table>

**Q21:** How often do you consume each of these almond forms or products?
Flavor

• How different are almond varieties?
What Differentiates Almonds - Flavor Profile – Key Sensory Attributes for Almonds

Key Flavors and Differentiators:
- **Amaretto flavor**: key flavor differentiator between varieties
- **Sweet Aromatic flavor**: **
- **Marzipan/Benzaldehyde flavor**: **
- **Musty/Earthy flavor**: **
- **Woody flavor**: **
- **Unripe/Beany flavor**: (NSD)
- **Hay flavor**: **

Confidence Levels:
- * 90% Confidence Level (Duncan's)
- ** 95% Confidence Level (Duncan's)

NSD: Not Significantly Different

Covance, 2015, unpublished
Why and Where is Flavor Important?

Consistent consumer experience is important

Food Categories
- Low almond flavor desired
  1. Almond Milk
  2. Almond flour/meal, for baking and gluten free cooking

Food Categories
- Strong almond flavor/aroma desired
  1. Snacking
  2. Chocolate
  3. Almond butter
  4. Baking
Case Studies For Flavor – Adding Value Across Grocery Aisles

- Tomatoes
  - Garden versus heirloom

- Olive Oil
  - Regular versus Extra Virgin Olive Oil

- Potatoes
  - Russet versus Yukon

- Lettuce
  - Iceberg versus Arugala/Kale

- Ancient Grains
  - Wheat versus quinoa

- Apples
Summary

• Almond versatility is highlighted by the breadth of use as a snack and ingredient
• Consumers rate taste as the number one attribute when selecting nuts
• Almonds have the greatest association with snacking versus any other nut
• Almonds get their distinct flavor from benzaldehyde (Marzipan) flavor and is a key differentiator among varieties
• Almonds can play well across multiple categories and consistency of consumer experience is important
Dani Lightle, University of California
Almond Varieties: Field Perspective

Dr. Dani Lightle
Orchard Systems Advisor
UC Cooperative Extension, Glenn, Butte & Tehama Cos.
Today we’re talking about:

• What makes the Ideal Variety?
• Considerations for variety selection
• Marketing classification and value
• Current planting trends
In pursuit of the Ideal Varieties
What makes some varieties better than others?
Considerations:

1. Fertilize the nut
Considerations:

2. Grow the nut (and tree)
Considerations:

3. Harvest the nut
Considerations

4. Sell the nut

- Consistency
- Marketing classification
- Quality
- Price
Considerations

Risk level
Aesthetics

5. Know yourself
Considerations

Pollen compatibility
Relative bloom periods
Number of shakes
Relative harvest timing
Ease of removal
Risk level
Aesthetics
Consistency
Marketing classification
Quality
Price
Insects
Diseases
Genetic disorders
Rootstock compatibility
Risk level
Aesthetics
Consistency
Marketing classification
Quality
Price
Insects
Diseases
Genetic disorders
Rootstock compatibility

Ideal Varieties

University of California
Agriculture and Natural Resources
Considerations for Selecting Almond Varieties
In general, almonds are self-incompatible.

Newer varieties may be self-fertile (e.g., Independence; Shasta) or partially self-fertile (e.g., Winters).

Virtually every variety commonly planted is compatible with Nonpareil.

Consult a pollen compatibility chart.
Fertilize the nut

Increased frost risk with early blooming varieties (especially northern regions)

Avoid poor overlapping bloom

Consult a chart of approximate bloom periods
Grow the nut & tree

<table>
<thead>
<tr>
<th>Compatibility with Marianna 2624</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate</td>
</tr>
<tr>
<td>Butte</td>
</tr>
<tr>
<td>Monterey</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Rootstock Compatibility

- Historically problematic with Marianna 2624

Compatibility with Krymsk 86

Monterey - sporadic reports of incompatibility
Grow the nut & tree

Compatibility with Marianna 2624

<table>
<thead>
<tr>
<th>Variety</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate</td>
<td>Incompatible</td>
</tr>
<tr>
<td>Butte</td>
<td>Livingston</td>
</tr>
<tr>
<td>Monterey</td>
<td>Marcona</td>
</tr>
<tr>
<td></td>
<td>Nonpareil</td>
</tr>
</tbody>
</table>

Variety and rootstock must have compatible licensing.

May depend on nurseries and/or patent holders.

Compatibility with Krymsk 86

Monterey - sporadic reports of incompatibility

University of California
Agriculture and Natural Resources
Grow the nut & tree

Avoid known genetic disorders

### Varieties with known Noninfectious Bud Failure potential

<table>
<thead>
<tr>
<th>Variety</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carmel</td>
<td>Peerless</td>
</tr>
<tr>
<td>Mission</td>
<td>Price</td>
</tr>
<tr>
<td>Nonpareil</td>
<td>Winters</td>
</tr>
</tbody>
</table>
Grow the nut & tree

Varieties are differentially susceptible to insects and pathogens

Learn site history or talk to neighbors
Harvest the nut

Harvest timing

- Your equipment vs contract harvesting?
- Acreage & timing of other harvests in your operation
- Overlap within an orchard & potential for mixed nuts

Consult a harvest timing chart
Harvest the nut

Harvest timing

- Your equipment vs contract harvesting?
- Acreage & timing of other harvests in your operation
- Overlap within an orchard & potential for mixed nuts

Consult a harvest timing chart

<table>
<thead>
<tr>
<th>Easy</th>
<th>Difficult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butte</td>
<td>Fritz (if shaken too early)</td>
</tr>
<tr>
<td>Ne Plus Ultra</td>
<td>Mission (young trees)</td>
</tr>
<tr>
<td>Peerless</td>
<td>Padre (young trees)</td>
</tr>
<tr>
<td>Price</td>
<td>Winters</td>
</tr>
</tbody>
</table>
Harvest the nut

Fewer passes → $$$

Mixing incompatible varieties →

For example¹:

Mix:
Sonora inshell + Nonpareil inshell
Winters + Carmel
Monterey + Carmel

Do Not Mix:
Sonora meats + Nonpareil meats
Wood Colony with anything
Independence with anything

¹From: Variety Separations at Harvest. Blue Diamond 2016
Know yourself

Aldrich

Nonpareil

©Mel Machado 2016
Know yourself

Risk Taker or Risk Averse?

Reach for the Tried and True?

Or, tempted by what’s new?

Source: Socialogue™ by Ipsos Open Thinking Exchange, Powered by Ipsos Global @dvisor
<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonpareil Type</td>
<td>Thin outer shell, smooth kernel</td>
<td>Blanched, sliced, cut</td>
</tr>
<tr>
<td>California Type</td>
<td>Wide range of shapes &amp; characteristics; blanchable</td>
<td>Manufactured products</td>
</tr>
<tr>
<td>Mission Type</td>
<td>Hard shells; small, wide, plump kernels, wrinkled</td>
<td>Salted and/or other seasonings; ice cream</td>
</tr>
<tr>
<td>Carmel Type</td>
<td>Long, narrow, light colored</td>
<td>Roasting</td>
</tr>
<tr>
<td>Inshell – Hard Shell</td>
<td>Closed, hard, corky shell</td>
<td>Hand crack</td>
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</tbody>
</table>
## Marketing Classes

<table>
<thead>
<tr>
<th>Variety</th>
<th>Nonpareil</th>
<th>California</th>
<th>Carmel</th>
<th>Mission</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>Butte</td>
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<td>Carmel</td>
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<td>Fritz</td>
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<td>Mission</td>
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</table>

<table>
<thead>
<tr>
<th>Variety</th>
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<th>Carmel</th>
<th>Mission</th>
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<tr>
<td>Padre</td>
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<td></td>
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<td>Wood Colony</td>
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Crop Payout History

Data from the Blue Diamond Growers payment history.
Crop Payout History

Relative value of marketing classifications:
- Nonpareil type
- Carmel type
- California type
- Mission type

Data from the Blue Diamond Growers payment history.
Current Planting Trends
% of Acreage Planted by Variety

- **Nonpareil**
- **Carmel**
- **Butte**
- **Monterey**
- **Padre**
- **Price**
- **Fritz**
- **Sonora**
- **Mission**
- **Wood Colony**
- **Aldrich**
- **Independence**
- **Supareil**

- **1990**
- **2000**
- **2010**
- **2015**

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% of Acreage Planted by Variety

- Nonpareil
- Carmel
- Butte
- Monterey
- Padre
- Price
- Fritz
- Sonora
- Mission
- Wood Colony
- Aldrich
- Independence
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Final thoughts

- Many factors play into the success of any given variety *in your operation*
- What works for your neighbor may not work for you!
- Seek out resources
  - Almond Production Manual
  - thealmonddoctor.com
  - sacvalleyorchards.com
  - Your local CE advisor
Thank you for your attention!

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