Almond Breeding: Important issues and challenges for research


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Why breed almonds?

Solve **problems** by releasing new cultivars

- California and Australia: High productivity.
- Mediterranean countries: Low productivity.
  - Lost of production by frost.
  - Problems during pollination.
  - Rainfeed culture or low irrigation.
Cultivar situation

- California: Nonpareil (40%), Carmel, Butte, Monterrey, etc.
- Australia: Nonpareil (50%), Carmel, Prize.

- Mediterranean and other countries:
  - A lot of authochtonous cultivars.
  - New cultivars from breeding programs:
    - Late blooming
    - Self-compatible
# Results of breeding programs: the “new” cultivars

<table>
<thead>
<tr>
<th>INRA</th>
<th>CITA</th>
<th>IRTA</th>
<th>CEBAS-CSIC</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferragnès</td>
<td>Ayles</td>
<td>Francolí</td>
<td>Antoñeta</td>
<td>Avalon</td>
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<tr>
<td>Ferraduel</td>
<td>Guara</td>
<td>Masbovera</td>
<td>Marta</td>
<td>Carmel</td>
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<tr>
<td>Lauranne</td>
<td>Moncayo</td>
<td>Glorieta</td>
<td>Penta</td>
<td>Butte</td>
</tr>
<tr>
<td>Mandaline</td>
<td>Blanquerna</td>
<td>Vayro</td>
<td>Penta</td>
<td>Padre</td>
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<tr>
<td>Cambra</td>
<td></td>
<td>Constantí</td>
<td>Price</td>
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<tr>
<td>Felisia</td>
<td>Marinada</td>
<td></td>
<td>Sonora</td>
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<tr>
<td>Soleta</td>
<td>Tarraco</td>
<td></td>
<td>Sweetheart</td>
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<tr>
<td>Belona</td>
<td></td>
<td></td>
<td>Winter</td>
<td></td>
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<tr>
<td>Mardía</td>
<td></td>
<td></td>
<td>Independence</td>
<td></td>
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<tr>
<td>Vialfás</td>
<td></td>
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<td>Folsom</td>
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</tbody>
</table>
Other important results: scientific research

- **Genetic control:**
  - Quantitative traits: Flowering, Maturity,…
  - Qualitative traits: Self-compatibility, Bitterness.

- **Floral biology:**
  - Self-incompatibility.
  - Solid orchards with self-compatible cultivars.

- **Molecular markers:**
  - Identification of cultivars (SSRs).
  - Early selection (locus S).

- **Other informations:** Resistance, quality, etc..
Some practical examples for breeding

- **Predicting the values of seedlings.**
  - Most of quantitative traits have high $h^2$.

- **Assuring self-compatibility in the offspring.**
  - $SfSf$, sharing $Si$-allele, self-pollination.

- **Avoiding bitter seeded seedlings.**
  - Use of homozygous SS.

- **Early selection of self-compatible seedlings.**
  - PCR allele specific of S-locus.
Early selection of self-compatible seedlings
Biotechnological advances: Marker Assisted Selection
Simulation of early selection

<table>
<thead>
<tr>
<th>Self-compatibility (Sₓ,Sᶠ x SᵧSᶻ)</th>
<th>Self-incompatible</th>
<th>Self-compatible</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>500</td>
<td>500</td>
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<tr>
<td>Bitternes (Sₛ x Sₛ)</td>
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</tr>
<tr>
<td>Bitter</td>
<td>125</td>
<td>125</td>
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<tr>
<td>Sweet</td>
<td>375</td>
<td>375</td>
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<tr>
<td>Flowering time (&gt; or &lt; mean population)</td>
<td></td>
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</tr>
<tr>
<td>&lt;ₓ 63</td>
<td>&gt;ₓ 63</td>
<td>&lt;ₓ 188</td>
</tr>
<tr>
<td>&gt;ₓ 63</td>
<td>&lt;ₓ 188</td>
<td>&gt;ₓ 188</td>
</tr>
</tbody>
</table>

1.000 seedlings
Selection of seedlings in the orchard

Flowering

Productivity

Fruits traits
Fingerprinting of cultivars (SSRs)

- Check authenticity of cultivars.
  - Different “Marconas” and “Desmayos”
  - Felipa = Filippo Ceo
  - Guara = Supernova = Tuono

- Protect the registered cultivars.
New breeding objectives for the future

- Early ripening (short cycle).
- Resistance to diseases and pests.
- Kernel quality for specific uses.
- Cultivars for each culture model.

PRODUCTIVITY

Kg/ha
€, $, Dirham/ha
Breeding for productivity

![Graph showing demand and supply from 2007 to 2025]

- **Demand**
- **Supply**
Breeding for early ripening

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Fruct</th>
<th>Penta</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
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<tr>
<td>Rojo Pasión</td>
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<td>-61</td>
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Breeding for resistance

- **Important pest and diseases:**
  - Navel orangeworm, Capnode…
  - Monilinia, Polystigma, Fusicoccum, Pseudomonas, Verticillium…

- **Benefits:**
  - Reduction of costs.
  - Environmentally friendly.
  - Healthier kernels.

- **Difficulties:**
  - Sources of resistance (other species).
  - Genetic control and inheritance.
  - Isolation and handling of pathogen.
  - Effect of environment.
Breeding almonds for each use
Breeding cultivars for each orchard model

- Modern irrigated orchards.
  - High production.

- Traditional rainfed culture.
  - Self-compatibility.
  - Resistance to drought and diseases.

- New high density plantations.
  - High and early production.
  - Low vigour.
  - Good ramification.
The final real test:
The experimentation in culture areas

- Frequently, new released cultivars are not significantly planted or even pulled off.
- Cultivars may behave different in each area and culture conditions.
- Performance of each cultivar is related to grower knowledge.

Please, be sure of the performance of the cultivar before planting!!!
Not one man in a thousand has accuracy of eye and judgment sufficient to become an eminent breeder. If gifted with these qualities, and he studies his subject for years, and devotes his lifetime to it with indomitable perseverance, he will succeed, and may make great improvements; if he lacks any of these qualities, he will assuredly fail.

Charles Darwin 1859
The Origin of Species