Breeding Peanuts: The Story of a Lowly Groundnut

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Arachis hypogaea L.

- Annual legume
- Self pollinated
- Indeterminate
- Genetics
  - Cultivated = allotetraploid
    - $2n = 4x = 40$
    - A and B genomes
  - Wild = diploid
    - $2n = 2x = 20$ (66 species)
    - $2n = 4x = 40$ (1 species)
- Botanically - Fabaceae
- Culinary- nut family
- Oil crop
Origin and Dispersion

Origin: Tropical South America: Bolivia, Brazil, Argentina
Adaption: Tropical, sub-tropical climates

Peanut plants produce flowers above ground and seeds below ground
Digging Peanuts
Peanut pods are dried after harvest in wagons

Peanut pods are stored in large warehouses
USA – about 500,000 HA

Four states produce 80% of US peanuts

.... Average planted acreage 2010-2014
World - about 24,000,000 HA

Source: http://gaez.fao.org/Main.html
### Market and botanical types of peanut

<table>
<thead>
<tr>
<th>Sub-species</th>
<th>hypogaea</th>
<th>hirsuta*</th>
<th>fastigiata</th>
<th>vulgaris</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VARIETY</strong></td>
<td><strong>hypogaea</strong></td>
<td><strong>hirsuta</strong></td>
<td><strong>fastigiata</strong></td>
<td><strong>vulgaris</strong></td>
</tr>
<tr>
<td>U.S. MARKET TYPE</td>
<td>Flowers on laterals</td>
<td>peanut butter, oil, candy</td>
<td>Flowers on mainstem &amp; laterals</td>
<td>valencia roasted in shell or boiled</td>
</tr>
<tr>
<td>Runner</td>
<td>roasted salted or in shell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td></td>
<td></td>
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</tbody>
</table>

*Not grown commercially in the United States*

UF Program: Runner types (85%), Virginia types (10%), Valencia types (5%)

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### Peanut in the USA is a food
Peanuts have a cultural bias

- George Washington Carver
- Mr. Peanut - Planters
- Many names
  - Peanut, Groundnut, Goober
  - Mani (Spanish), Pindar
- Various cultural preparations
  - USA
    - Peanut butter, Candies, Whole nuts, in-shell
  - Asia (China, India)
    - Cooking oil, whole nuts
  - South America
    - Roasted whole, beverage
    - Large amounts exported

Breeding programs in USA

- Over 99% of cultivars publicly bred
  - New Mexico State Univ.
  - Texas A&M Univ.
  - USDA - Oklahoma State Univ.
  - Auburn Univ.
  - University of Florida
  - University of Georgia
  - USDA - University of Georgia
  - Clemson Univ.
  - North Carolina State Univ.
Breeding Goals: A peanut variety must satisfy several major customers

**Consumer**
Healthiness and flavor are keys to peanut consumption

**Farmer**
Seed vigor, Yield, Grade, Disease res.

**Traits we measure**
Yield, grade, pod/seed size, disease resistance, oil quality

**Manufacturer**
Uniformity, blanching, Roasted FLAVOR, Oil Chemistry, Low Aflatoxin

**Sheller**
Uniform size, easy to shell and process

**Traits needing better measures**
Germination, oil concentration, flavor, antioxidants, protein, reaction to drought, Virginia- pod color

Target Traits in Peanut Breeding

Peanut yields in Florida have increased over the past 5 years (2010-14). One ton = $400-600

Peanut production in Florida, 1909-2014

Value in 2012 ~ $170 million
Partial output from the grading process

USDA value of peanut determined by the “grade” or percentage of Total Sound Mature Kernels (TSMK %)

<table>
<thead>
<tr>
<th>Number 1</th>
<th>Medium</th>
<th>Jumbo</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-99R</td>
<td>4%</td>
<td>30%</td>
</tr>
<tr>
<td>GA Green</td>
<td>7%</td>
<td>45%</td>
</tr>
</tbody>
</table>

TSMK% ranges from 74-80%

Every point in TSMK = about $5 in value

Breeding for disease resistance

“if a new disease-resistant variety is to be acceptable to farmers, it must yield fully as well as the old, susceptible variety in all features that influence the net value of the crop even when disease is absent”. (ANDRUS, 1953)
Planted in Marianna, early April, 2004

Highly resistant breeding line

TSWV
White Mold

*Sclerotium rolfsii*

White Mold

White Mold
### Chemical composition of peanut seeds

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>5-8</td>
</tr>
<tr>
<td>Oil</td>
<td>44-56</td>
</tr>
<tr>
<td>Protein</td>
<td>25-34</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>6-25</td>
</tr>
<tr>
<td>Fiber</td>
<td>1.6-1.9</td>
</tr>
<tr>
<td>Ash</td>
<td>1.8-2.9</td>
</tr>
</tbody>
</table>

**Interested in oil quality, not quantity**

<table>
<thead>
<tr>
<th>Fatty Acids</th>
<th>Normal Oleic</th>
<th>High Oleic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oleic</td>
<td>37 - 80%</td>
<td>50-60%</td>
</tr>
<tr>
<td>Linoleic</td>
<td>2 - 43%</td>
<td>15-25%</td>
</tr>
</tbody>
</table>

High oleic peanuts delayed rancidity by 28 weeks (PV of 20 is considered unacceptable)

![Graph showing Peroxide Value vs. Storage Weeks for Normal Oleic and High Oleic peanuts]

**Fig. 1.** Shelf life of roasted inshell normal vs. high oleic peanut.

Measuring oil and fatty acids

- Gas chromatography (GC)
  - Accurate
  - Always destructive/injurious
  - Time consuming (15-20 min./sample)

- Near infrared reflectance (NIR)
  - Less accurate
  - Non-destructive
  - Fast (3-5 min./sample)

Iteration 1 validation: Oleic Acid
4 out of 43 HO kernels were misclassified by NIR

\[ R^2 = 0.84 \]
\[ y = 1.01x - 2.0 \]
Slope: \( p>|t|<0.0001 \)
Intercept: \( p>|t| = 0.9475 \)
\( n = 95 \)
Breeding Process & Program Philosophy

<table>
<thead>
<tr>
<th>Research to Improve Processes</th>
<th>Ultimate Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIR to predict chemistry</td>
<td>Improved Cultivars</td>
</tr>
<tr>
<td>Predict seed quality</td>
<td></td>
</tr>
<tr>
<td>Improve efficiency of basic tasks</td>
<td></td>
</tr>
<tr>
<td>Identify new germplasm with advantageous traits</td>
<td></td>
</tr>
<tr>
<td>New germplasm with disease resistance</td>
<td></td>
</tr>
<tr>
<td>Transgenics, Molecular markers</td>
<td></td>
</tr>
</tbody>
</table>

Peanut flowers are self-pollinating

Figure 10-2 (a) Peanut inflorescence with flower in leaf axil, and (b) longitudinal schematic drawing of the flower. From Hybridization in Crop Plants, p. 447, by permission of the Crop Science Society of America and American Society of Agronomy. (After Smith, 1950)

3-4 pm emasculate
7-8 am pollinate
Crossing is tedious

Cultivar Development Process:
pedigree method, early generation testing, one generation per year

- **Visual Selection**
  - 80-90 crosses per year
  - F₁ in Citra, FL, NIR for oleic
  - F₂ & F₃ in Marianna
    - Selected for pod, TSWV, FA
  - F₃:4 in Marianna - generation adv.
    - F₃:4 in Citra - yield and grade
  - F₄:5 in Marianna, Citra
    - Yield and grade, FA
  - F₄:6 Yield/Grade-optimal
    - TSWV, leafspot, CBR, nematode

- **Data-driven selection**
  - F₄:7
    - 2-3 location YT: MR, GV, JY
      - Optimal & disease conditions
  - F₄:8
    - 2-3 location YT: MR, GV, JY
      - Optimal & disease conditions
  - F₄:9
    - 1) 3 loc. YT: MR, GV, JY
      - Optimal conditions
    - 2) YT: TSWV, White Mold, CBR, nematode, leafspot
    - 3) Three best lines in the UPPT

- **Release decision:** 8-9 years
- **Seed Production:** 3 years

- 6000 YT plots
- 2400 BN iplots
Research and testing sites

- Breeding/Testing Sites:
  - Jackson Co. 40-45 A
  - Alachua Co. 12-15 A

Primary Test Sites

On-Farm Testing

An example of Cultivar Development:
Timelines leading up to TSWV epidemic

- 1971: PI203396- leafspot resistant
- 1972: PI203396 crossed with Florunner
- 1984: Southern Runner released
- 1985/-: Southern Runner crossed with Sunbelt Runner
- 1995: Georgia Green released
- 1997-96: Tomato Spotted Wilt Virus causes severe losses
- 1972-96: Florunner, GK-7, etc. Most very susceptible to TSWV
- 1997-04: Georgia Green, C-99R Both have PI203396 in parentage
- Southern Runner discovered to have resistance to TSWV derived from PI203396
Peanut yields in USA have increased over time

Why did yields improve dramatically in 1960's?
1) New pesticides – early 1960's
2) New agronomic techniques
3) New varieties - late 1960’s – early 70's

Why was yield stagnant 1975-1996?
1) Same or similar varieties & pesticides
2) Politics - Farm Bill
   • Discouraged crop rotation

What has driven yield improvement since 2000?
1) Improved pesticides
2) Crop rotation
3) Varieties
4) Politics - Farm Bill - 2002
   • Improved crop rotation
   • Expanded production areas

Contributing factors?
Plant introductions used in peanut breeding

PI203396

<table>
<thead>
<tr>
<th>Parent</th>
<th>Southern Runner</th>
<th>C-99R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent</td>
<td>Southern Runner</td>
<td>Georgia Green</td>
</tr>
<tr>
<td>Grandparent</td>
<td>Tifrunner</td>
<td>Georgia-09B</td>
</tr>
<tr>
<td>Great grandparent</td>
<td>Georgia-12Y C-99R</td>
<td>Tif.Runner 727</td>
</tr>
<tr>
<td></td>
<td>Georgia-01R</td>
<td>TUFRunner 511 présap</td>
</tr>
<tr>
<td></td>
<td>Tifrunner</td>
<td>TIFRunner 511 présap</td>
</tr>
</tbody>
</table>

Implications:
1) better disease resistance and yield potential
2) more variation in seed size and seed vigor
3) more variation in maturity

Over 90% of SE acreage

Florida-07 FloRun 107
Georgia-06G
Georgia-07W
Georgia Greener Tifguard
TUFRunner 511
York

Georgia-13M
TUFRunner 727
Georgia-03G
Florida-07
FloRun 107
Georgia-06G
Georgia-07W
Georgia Greener Tifguard
Annual Meeting

“Identifying and utilizing genetic diversity”

27-30 July 2015, WSU Pullman, WA

https://www.plantbreeding.org/annual-meeting-2015

Registration Deadline- June 1st