1. Uses and Benefits of Guar as a Crop
2. History of Guar Varieties in the U. S.
3. Breeding Objectives
4. Breeding Approach
1. Guar Cultivation

- Uses of Guar
- Guar as a Crop
Uses of Guar

- Gum - galactomannan
  - food thickening agent – ice cream, yogurt, sauces, cheese
  - Industrial - paper, pharmaceuticals, cosmetics
  - Hydraulic fracturing in oil extraction
- Forage crop
- Immature pods as source of food for human consumption
- Rotational Crop
Guar as a Crop

- Annual row crop
- Enriches soil - nitrogen fixing?
- Adapted to mechanical planting, cultivation and harvesting
- Product expands industrial non-food use market
- Adapted to water-limited environments
- Low input costs
2. Guar Varieties in the U.S.

- Early History
- Varieties Released the Past 50 Years
Early History of Guar in the U.S.

1906 - Introduced from India
- initially for forage, later tried for gum production
- irrigated production tried in AZ, NM, unprofitable
- low yields, late maturity (120-145 d), need for irrigation (2 acre-feet?), undeveloped markets

World War II- renewed interest for gum
- irrigated production in NM, AZ
- experiment station yields 1,200-2,600 lbs./acre
- contracted acreage payments
- dryland production tested outside San Antonio
- new varieties with higher yield, branched stalk, or earlier maturity
# Earliest Varieties

<table>
<thead>
<tr>
<th>Texsel</th>
<th>Mesa</th>
</tr>
</thead>
<tbody>
<tr>
<td>non-branching</td>
<td>branching</td>
</tr>
<tr>
<td>set seed mid-summer</td>
<td>late flowering</td>
</tr>
<tr>
<td>matured 1 month earlier</td>
<td>late maturing, pods slow to dry out</td>
</tr>
<tr>
<td>lower yield potential</td>
<td>higher yield potential</td>
</tr>
<tr>
<td>first pods set low to ground</td>
<td>first pods higher off ground</td>
</tr>
</tbody>
</table>

Source: R. L. Matlock and D. C. Aepli, Growth and Diseases of Guar (1948), Arizona AES Bulletin #216
History (continued)

• Post - WWII
  • Reduction in acreage in AZ, NM
    • loss of crop guarantees, loss of industrial outlets
  • Dryland production demonstrated in TX and OK
    • SE TX, summer legume following flax
      • processing plant in Kenedy (SE of San Antonio)
      • delayed rain --> poor germ, fall rains --> delayed harvest --> blackened seed NG for gum
    • NW TX (Vernon), SW OK, dryland
      • good match for rainfall and soil type
      • rotation with cotton increases cotton yields
      • yields 500-1000 lb/ac
## Varieties Released in Past 50 Years

<table>
<thead>
<tr>
<th>Name</th>
<th>Released</th>
<th>Developers</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brooks</td>
<td>1964</td>
<td>Stafford, Kinman, Brooks, Lewis</td>
<td>USDA, TAES, OAES</td>
</tr>
<tr>
<td>Hall</td>
<td>1966</td>
<td>Stafford, Kinman, Brooks, Lewis</td>
<td>USDA, TAES, OAES</td>
</tr>
<tr>
<td>Mills</td>
<td>1966</td>
<td>Stafford, Kinman, Brooks, Lewis</td>
<td>USDA, TAES, OAES</td>
</tr>
<tr>
<td>Kinman</td>
<td>1975</td>
<td>Stafford, Kirby, Kinman, Lewis</td>
<td>TAES, USDA, OAES</td>
</tr>
<tr>
<td>Esser</td>
<td>1975</td>
<td>Stafford, Kirby, Kinman, Lewis</td>
<td>TAES, USDA, OAES</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>1984</td>
<td>Ray, Stafford</td>
<td>UAz, USDA</td>
</tr>
<tr>
<td>Lewis</td>
<td>1984</td>
<td>Stafford, Ray</td>
<td>TAES, UAz</td>
</tr>
<tr>
<td>Matador</td>
<td>2004</td>
<td>Peffley, Auld, Norman</td>
<td>TTU, Halliburton</td>
</tr>
<tr>
<td>Monument</td>
<td>2004</td>
<td>Peffley, Auld, Norman</td>
<td>TTU, Halliburton</td>
</tr>
</tbody>
</table>
### Themes in Varietal Development (Older Varieties)

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Disease</th>
<th>Yield, acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brooks</td>
<td>branching, lower pods higher above ground</td>
<td>bacterial blight &amp; Alternaria leaf spot resistant; later susceptible to bacterial blight</td>
<td>43% higher yield than Texsel Groehler, grown on &gt;95% of U.S. acreage in 1970s</td>
</tr>
<tr>
<td>Hall</td>
<td>branching, tall, late</td>
<td>bacterial blight &amp; Alternaria leaf spot resistant</td>
<td>single plant selection from PI</td>
</tr>
<tr>
<td>Mills</td>
<td>branching, short, early</td>
<td>bacterial blight &amp; Alternaria leaf spot resistant</td>
<td>single plant selection from PI</td>
</tr>
<tr>
<td>Kinman</td>
<td>branching, medium-tall, medium maturity</td>
<td>moderate resistance to bacterial blight; later said susceptible</td>
<td>Brooks x Mills; yield 20% greater than Brooks, 95% of AZ acreage</td>
</tr>
<tr>
<td>Esser</td>
<td>medium height, limited branching, medium maturity</td>
<td>bacterial blight resistant</td>
<td></td>
</tr>
</tbody>
</table>
### Themes in Varietal Development (Newer Varieties)

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Traits</th>
<th>Yield, acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lewis</td>
<td>branching, medium height &amp; maturity, sequential flowering</td>
<td>bacterial blight resistant similar to Esser &amp; Hall, more resistant than Brooks or Kinman</td>
<td>21-25% greater yield than Kinman and Esser</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>sparse branching, late maturing</td>
<td>yields better at high elevation, low temperature &amp; higher rainfall</td>
<td></td>
</tr>
<tr>
<td>Matador</td>
<td>branching (130 d)</td>
<td>MR Alternaria leaf spot</td>
<td>35% gum</td>
</tr>
<tr>
<td>Monument</td>
<td>single stem, early (85 d)</td>
<td>Susceptible to Alternaria</td>
<td>39% gum</td>
</tr>
</tbody>
</table>
Appearance at Harvest

Mills  Hall  Santa Cruz  Monument
3. Breeding Objectives

- Field Traits
  - Plant growth habit
  - Maturity
  - Yield
- Seed traits
  - Larger seed size
  - Gum content
- Disease resistance
- Potential for other markets
Field Traits

• Yield
  • Genetic yield potential has not changed in past 30 years, but other crops’ yields have increased

• Growth Habit
  • Optimal branching habit depends on cropping system (ex: wheat vs. cotton rotation)
  • Associated with yield, maturity

• Maturity
  • Early maturity desired if used as catch crop (plant later in the cropping season after another crop fails)
Seed Traits

• Seed size
  • typically 3.0 - 3.4 g/100 seed
  • Larger seed associated with greater % gum recovery

• Seed composition
  • Embryo, 45%
  • Seed coat, 15%
  • Endosperm, 40% -- gum 28%

• Gum content
  • Genetic variability exists for gum content
  • different fractions
  • overall mannose: galactose ratio 1.6:1

Disease resistance

• Alternaria leaf spot (Alternaria brassicae)
  • occurs during cool, wet weather
  • Can be important in more humid areas of cultivation (OK, Eastern TX) than in West TX, NM, AZ

• Bacterial blight

• Others observed but not thought to be widespread
  • Texas root rot - Phymatotrichum omnivorum
  • Sclerotium rot - Sclerotium rolfsii
  • Fusarium root rot - Fusarium sp.
  • Black root rot - Rhizoctonia rolani
  • Mosaic virus
  • Powdery mildew - Oidiopsis taurica
Potential for Other Markets

• Forage
  • Forage Value - TTU trials (Source: K. Imel MS thesis)
    • dry matter 3200-4600 kg/ha
    • crude protein 18.6 - 20.8%
    • ADF 20.1 - 26.9%
    • NDF 27.3 - 32.4%
  • Good dairy hay
    • 21-22% Crude protein (CP), <28% Acid detergent fiber (ADF), <35% Neutral detergent fiber (NDF)
  • Additional forage data, contact Dr. Alex Rocatelli, Oklahoma State Univ., alex.rocateli@okstate.edu

• Fresh vegetable
  • Eaten as fried green pods in India and Pakistan
  • Longer pods desirable – present in some PIs
  • Resistance to disease
4. Breeding Approach

- Evaluation of Texas Tech advanced and intermediate populations
- Other germplasm as potential sources of needed traits
- DNA markers
- Development of new populations for evaluation
Texas Tech Breeding Lines

• Populations:
  • Advanced population - 18 breeding lines
  • Intermediate Population - 48 breeding lines

• Traits:
  • Yield, seed size
  • Plant architecture, maturity
  • Disease resistance
  • Potential for forage, gum
Evaluation of other accessions

- **Plant Introductions**
  - PI station has 1458 *Cyamopsis* accessions
  - Materials being evaluated - 72 Plant Introductions, ca. 65 from diversity studied of J. Morris Genet Resour Crop Evol (2010) 57:985–993 in GA

- **Observation samples from TTU breeding program**
  - 131 lines being evaluated in field

- **Traits** - Yield, Plant Ht., Growth Habit, Pod length, Maturity, 100 Sd. Wt
Marker-Assisted Breeding

- Very little molecular data on guar – 1 EST, 1 RAPD, 1 AFLP paper
- Goals are
  - Develop DNA marker map
  - Identify markers (QTLs) for traits in segregating populations
- In peanut, have found markers associated with tolerance to water deficit stress
Summary

• Improved varieties increased yield of guar from the accessions originally introduced into the US, but yield remain at levels of 30 years ago
• Improvements in disease resistance have been also associated with yield increase
• Plant type is associated with yield, maturity, and efficiency in harvesting
• Genetic variability exists for these and other traits
• The AgriLife and TTU breeding program is evaluating existing populations with the goal of releasing improved varieties
• Germplasm evaluation is expected to identify potential parents
• Molecular analysis can accelerate breeding efforts