Guar Breeding—Past and Future

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Outline

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

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1. Guar Cultivation

- Uses of Guar
- Guar as a Crop

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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

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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

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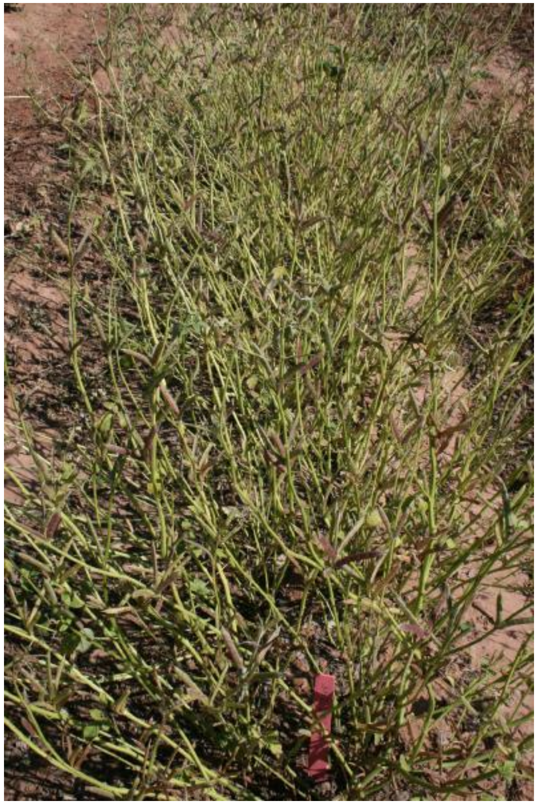
2. Guar Varieties in the U.S.

- Early History
- Varieties Released the Past 50 Years



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Early History of Guar in the U.S.

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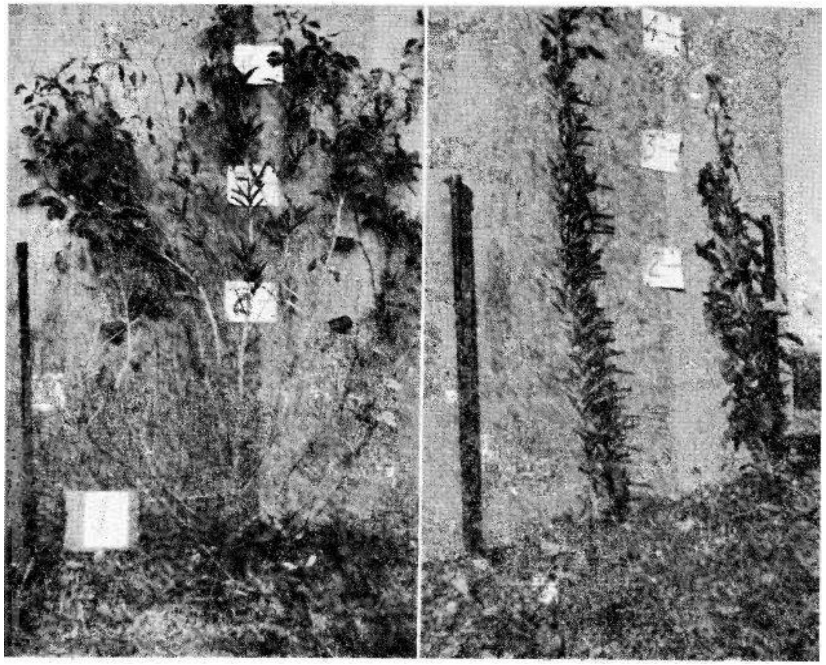
1906 - Introduced from India

- 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



Mesa Texsel

Texsel	Mesa
non-branching	branching
set seed mid-summer	late flowering
matured 1 month earlier	late maturing, pods slow to dry out
lower yield potential	higher yield potential
first pods set low to ground	first pods higher off ground

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

Name	Released	Developers	Organization
Brooks	1964	Stafford, Kinman, Brooks, Lewis	USDA, TAES, OAES
Hall	1966	Stafford, Kinman, Brooks, Lewis	USDA, TAES, OAES
Mills	1966	Stafford, Kinman, Brooks, Lewis	USDA, TAES, OAES
Kinman	1975	Stafford, Kirby, Kinman, Lewis	TAES, USDA, OAES
Esser	1975	Stafford, Kirby, Kinman, Lewis	TAES, USDA, OAES
Santa Cruz	1984	Ray, Stafford	UAz, USDA
Lewis	1984	Stafford, Ray	TAES, UAz
Matador	2004	Peffley, Auld, Norman	TTU, Halliburton
Monument	2004	Peffley, Auld, Norman	TTU, Halliburton

Themes in Varietal Development (Older Varieties)

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Name	Type	Disease	Yield, acreage
Brooks	branching, lower pods higher above ground	bacterial blight & Alternaria leaf spot resistant; later susceptible to bacterial blight	43% higher yield than Texsel Groehler, grown on >95% of U.S. acreage in 1970s
Hall	branching, tall, late	bacterial blight & Alternaria leaf spot resistant	single plant selection from PI
Mills	branching, short, early	bacterial blight & Alternaria leaf spot resistant	single plant selection from PI
Kinman	branching, medium-tall, medium maturity	moderate resist-ance to bacterial blight; later said susceptible	Brooks x Mills; yield 20% greater than Brooks, 95% of AZ acreage
Esser	medium height, limited branch-ing, medium maturity	bacterial blight resistant	

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Themes in Varietal Development (Newer Varieties)

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

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Appearance at Harvest

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Mills

Hall

Santa Cruz

Monument

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3. Breeding Objectives

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

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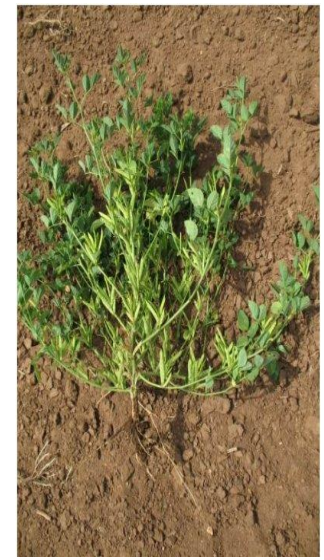
Field Traits

- 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)

Monument

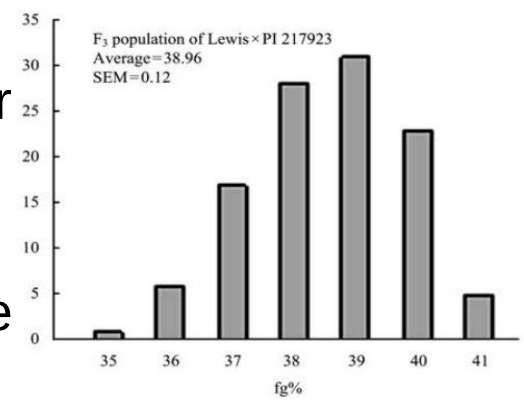


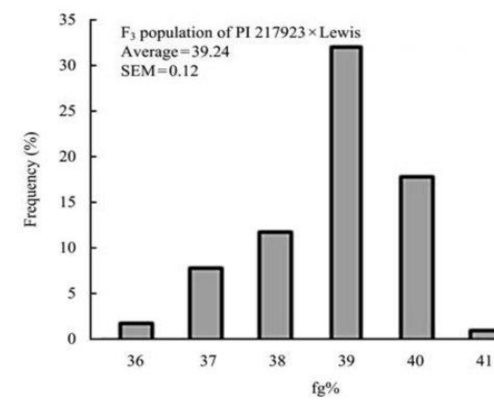
Matador

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

Source: C. Trostle, Guar in West Texas (2013)





Source: Liu et al. (2009) Agricultural Sciences in China 8:1517-1522 .

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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

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Texas Tech Breeding Lines

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- Populations:
  - Advanced population - 18 breeding lines
  - Intermediate Population - 48 breeding lines
- Traits:
  - Yield, seed size
  - Plant architecture, maturity
  - Disease resistance
  - Potential for forage, gum

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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

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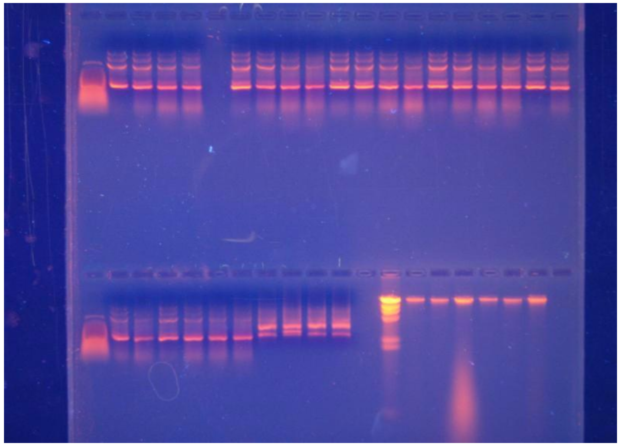
- Very little molecular data on guar – 1 EST, 1 RAPD, 1 AFLP paper
- Goals are
  - Develop DNA marker map
  - Identify markers (QTLs) for traits in segregating populations
- In peanut, have found markers associated with tolerance to water deficit stress



Summary

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- 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