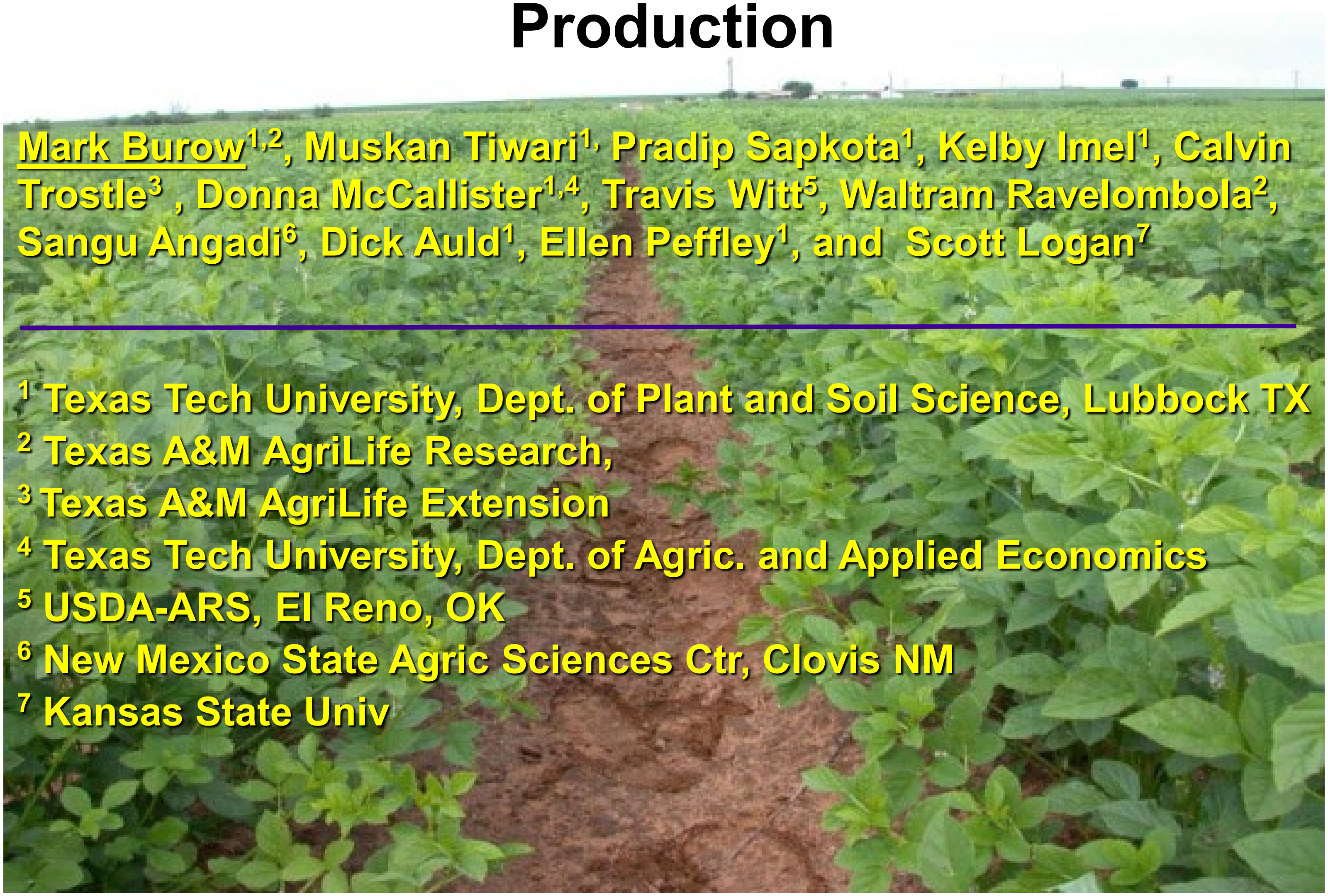
Improving Profitability of Guar as an Alternative Crop for Profitable Dryland Production



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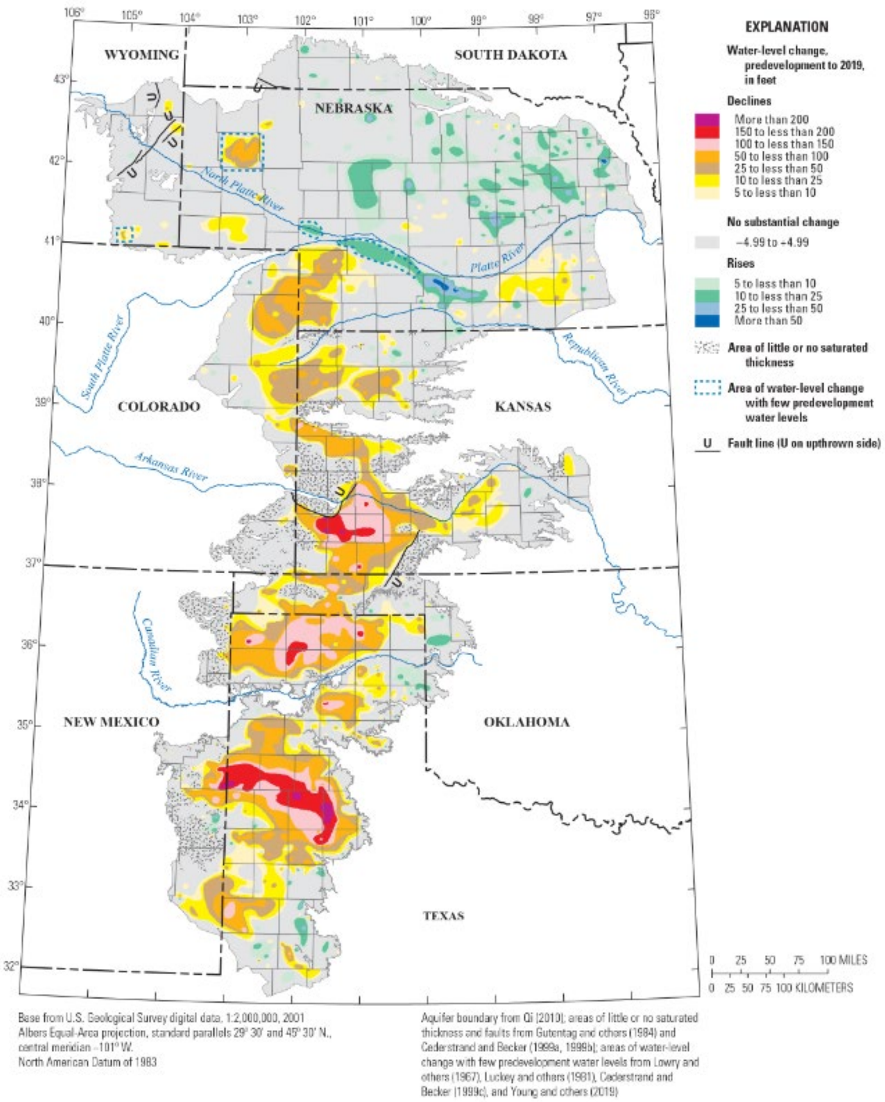
Outline

- Background to Guar
- Goals of Current Project
- Data
- Ongoing Work
- Conclusions

Needs

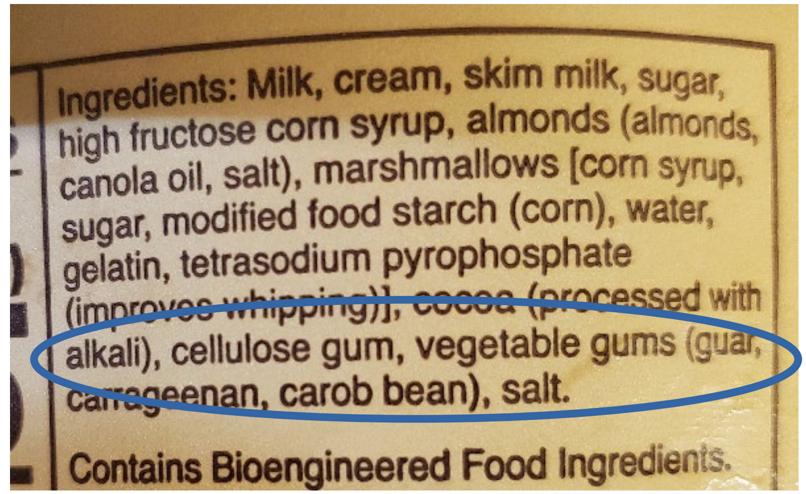
- Water-Efficient Crop
  - 2011 drought
  - Long taproot
  - Aquifer Levels
  - Crop Requirements
- Forage Legume
  - Crop Mix
  - Nitrogen
  - Adaptation

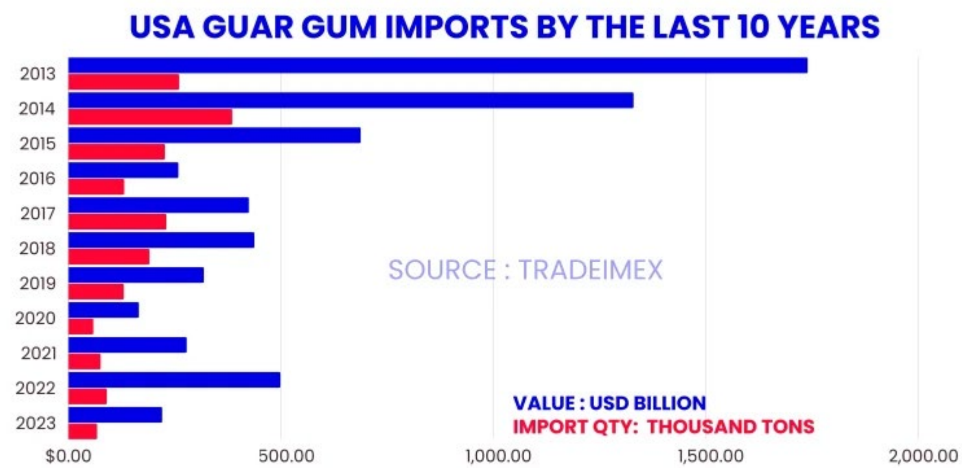


https://www.climatehubs.usda.gov/sites/default/files/Ogallala%20Overview%20241202.pdf

Guar as a Crop

- Uses
  - Food industry – thickening agent
  - Cosmetics and consumer products
  - Oil extraction -- fracking
- Volume Needed
  - US guar imports $109M to $1.74 billion, mostly from India. Italy, Spain
  - Tonnage varies 38K to 385 K tons
  - This represents about 101K to 1.0 M acres at 750 lb./ac (no assumptions about seed composition)
  - ca. 90% of US guar needs are imported





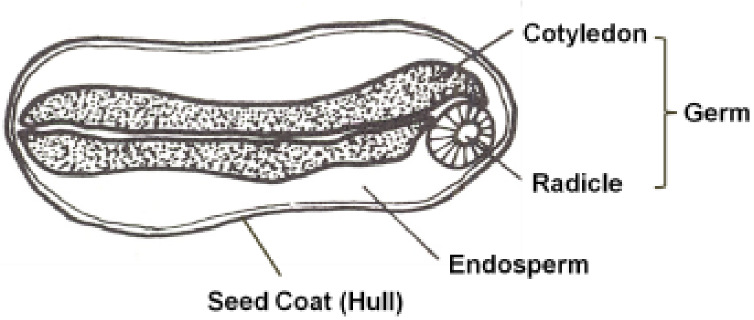
Price and Insurance

- Price
  - 2013 price was the highest ever, $0.45/lb. for standard Grade #1, has averaged ca. $0.15 to $0.20/lb (whole seed)
  - Price on splits (endosperm containing gum) shown below
- Crop Insurance
  - Currently no meaningful crop insurance (not a program crop)
  - Lending agencies may not lend money on guar without crop insurance

https://www.premcemgums.com/guar-splits-price-movement/#tab-id-4

Seed Composition

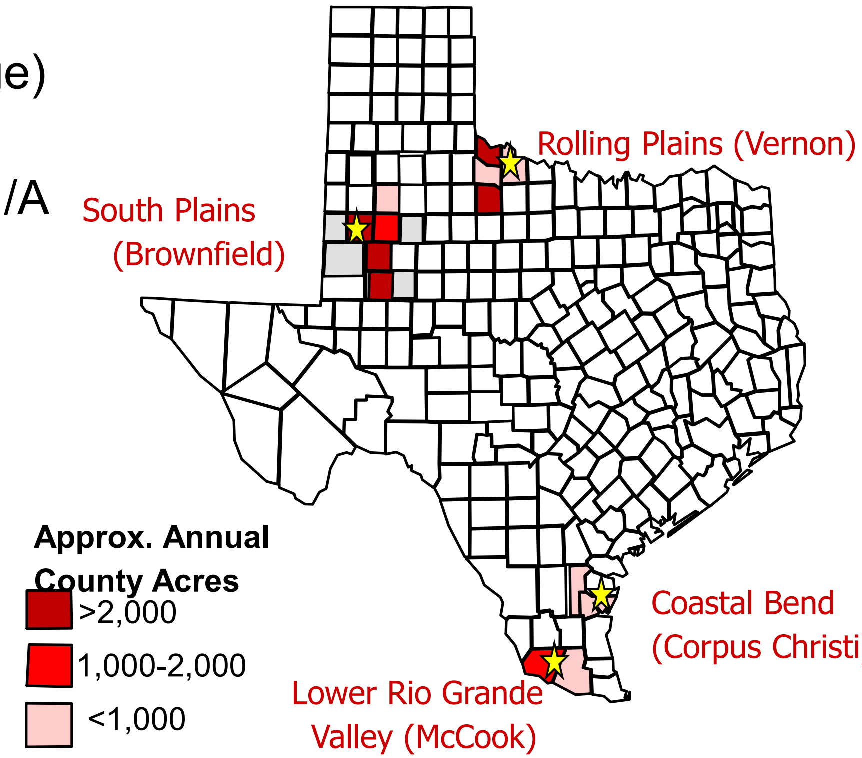
- Seed
  - Imported from India and Pakistan as 'splits'—endosperm (contains the galactomannan gum); seed coat and embryo removed.
  - Seed components are:
    - Embryo, 45%
    - Seed coat, 15%
    - Endosperm, containing the gum, 40%; about 28% of raw seed weight is extractable gum
  - Milling losses
- Other uses
  - Forage - India – guar as "cow food"
  - Pods as green vegetable – stir fry



Whistler, R.L., Hymowitz, T., (1979), Guar: Agronomy, Production, Industrial use and Nutrition (left)

Irrigation

- Irrigation and Yield
  - Dryland: 400-1,100 lbs./A (typical range)
    - But need a stand
  - Limited irrigation (3-6”): 800-1,400 lbs./A
  - Full irrigation? Up to about 2000 lb/ac
- Disease
  - bacterial blight
  - Alternaria leaf spot
  - Greater chance in humid environments
  - Monument susceptible



Varieties

- Varieties
  - Kinman, Lewis, Matador , Santa Cruz are most common varieties
  - Newest of these is 20 years old, Kinman released 50 years ago
  - Other crops- varietal life cyle 3-5 years, newer improved ones constantly released

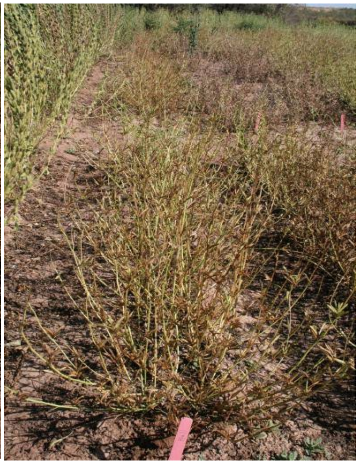
Varietal Name	Year Released	Developers	Organization
Brooks	1964	Stafford, Kinmand, Brooks, Lewis	USDA, TAES, OAES
Hall	1966	Stafford, Kinmand, Brooks, Lewis	USDA, TAES, OAES
Mills	1966	Stafford, Kinmand, Brooks, Lewis	USDA, TAES, OAES
Kinman	1975	Stafford, Kirby, Kinman, Lewis	TAES, USDA, OAES
Esser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

Goals of Current Project

1. Evaluate guar breeding lines to determine whether any can be released for seed production (seed yield, seed weight, disease resistance)
2. Determine quality and quantity of guar as forage
3. Determine whether guar can be grown in Kansas
4. Determine profitability of guar production for seed or silage
5. Gather yield data on farms - production function for crop insurance

1. Evaluation of Breeding Lines

Mills



Hall

Santa Cruz

Monument

Matador

Intermediate Line Test – Texas 2018-2019

Genotype	2018 Yield	lb/ac	2019 Yield	lb/ac	Mean Yield	lb/ac	Mean Seed Wgt	g/100	Mean Maturity	days
15GFT-541	1656	a-e	2281	a	1969		3.90		106	
15GFT-535	1624	a-f	2093	a-c	1859		4.10		122	
15GFT-511	1699	a-c	2017	a-d	1858		3.90		97	
15GFT-521	1444	a-i	1975	a-f	1710		4.28		106	
15GFT-523	1496	a-h	1875	a-h	1686		3.70		102	
15GFT-508	1405	a-i	1930	a-f	1668		3.93		107	
15GFT-522	1633	a-f	1670	b-h	1652		4.48		135	
Monument	1503	a-h	1748	a-h	1626		3.96		134	
15GFT-526	1730	ab	1494	d-h	1612		4.55		98	
Matador	1510	a-h	1706	a-h	1608		3.83		123	
15GFT-536	1586	a-g	1534	c-h	1560		4.63		134	
15GFT-533	1179	f-j	1880	a-h	1530		3.62		93	
Santa Cruz	1296	b-j	1748	a-h	1522		4.72		106	
15GFT-504	1435	a-i	1584	b-h	1510		4.42		134	
15GFT-547	1530	a-h	1468	c-i	1499		4.07		136	
15GFT-505	1430	a-i	1545	c-h	1488		3.80		98	
15GFT-529	1561	a-h	1268	h-j	1415		4.33		127	
HES2617	1134	g-j	1647	a-h	1391		3.53		106	
15GFT-540	908	j	1859	a-h	1384		3.85		113	
Lewis	1208	e-j	1322	f-j	1265		3.68		110	
Mean	1394		1667							
LSD	463		584							
CV (%)	20		21							
p-value	0.047		0.049							

Maturity

- Association with Plant Type
- Days to Maturity
- Row Spacing
- Yield
- No single “ideal” plant type for all circumstances

Single Stem

Small Bush

Large Bush

Oklahoma Testing – Intermediate Line Test

Genotype	2023 El Reno Yld(kg/ha)	2023 Woodward Yld(kg/ha)	2024 El Reno Yld(kg/ha)	2024 Woodward Yld(kg/ha)	Overall Mean Yld(kg/ha)	Overall Mean HSW g/100 Sd	Overall Mean Pct Mat Seed
15GFT-541	247	1628	1941	808	1156	3.68	71.9%
HES2617	1658	519	1568	478	1056	3.03	86.3%
15GFT-511	641	679	1782	924	1007	3.30	89.0%
15GFT-505	398	790	2002	781	993	3.11	75.8%
Lewis	682	941	1840	456	980	2.95	79.4%
Monument	853	775	1626	536	948	2.95	77.4%
15GFT-529	1082	775	1155	644	914	3.05	84.9%
15GFT-504	708	1568	972	217	866	2.76	79.0%
SantaCruz	527	731	1618	582	865	2.86	82.6%
15GFT-508	558	487	1439	698	796	2.92	63.9%
15GFT-533	259	644	1312	883	775	3.18	76.9%
15GFT-535	404	1072	1165	405	762	3.26	68.0%
Matador	199	517	1683	420	705	2.79	66.9%
15GFT-523	330	447	1322	692	698	3.00	67.4%
15GFT-526	73	748	1541	307	667	3.15	58.7%
15GFT-536	220	605	1267	412	626	3.36	69.6%
15GFT-521	255	534	911	760	615	3.42	67.8%
15GFT-540	353	745	786	338	556	3.13	63.5%
15GFT-522	227	330	1121	413	523	3.23	53.8%
15GFT-547	109	250	829	214	351	2.52	58.8%

Intermediate Line Test- Vernon, TX 2024

15GFT-504	1321	
15GFT-526	1168	
HES2617	1050	
15GFT-536	974	
Lewis	961	
15GFT-521	857	
SantaCruz	824	
15GFT-535	744	
15GFT-523	722	
15GFT-522	711	
15GFT-508	691	
15GFT-533	690	
Monument	687	
Matador	646	
15GFT-505	614	
15GFT-511	583	
15GFT-547	581	
15GFT-540	546	
15GFT-541	480	
15GFT-529	428	

Intermediate Line Test Under Water Deficit

	ARS Drt 2023		TALR Drt 2023		ARS Drt 2024	TALR Drt 2024	Means	
Genotype$	LbSeedAc		LbSeedAc		LbSeedAc	LbSeedAc	LbSeedAc	Wgt100Sd
15GFT-523	205	e-h	390	a-c	565	1,088	562	4.12
15GFT-504	433	ab	255	b-d	543	856	522	3.80
HES2617	295	a-g	366	a-c	286	892	460	3.59
15GFT-536	319	a-f	238	cd	453	781	448	4.29
15GFT-529	280	b-g	304	b-d	691	480	439	3.61
Monument	324	a-f	187	cd	366	772	412	3.72
SantaCruz	340	a-e	77	d	173	1,044	409	3.18
Matador	367	a-d	157	cd	482	576	396	3.74
15GFT-535	249	c-h	398	a-c	251	608	377	4.19
Lewis	390	a-c	271	b-d	268	550	370	3.92
15GFT-533	368	a-d	365	a-c	--	--	366	3.81
15GFT-540	309	a-g	98	d	360	681	362	3.88
15GFT-541	177	f-h	179	cd	212	870	360	4.45
15GFT-547	174	f-h	159	cd	175	853	340	4.01
15GFT-522	208	d-h	215	cd	437	485	336	4.31
15GFT-521	153	gh	252	b-d	282	658	336	4.44
15GFT-505	455	a	581	a	78	95	302	3.78
15GFT-511	249	c-h	355	a-c	--	221	275	4.44
15GFT-526	107	h	506	ab	--	211	274	3.92
15GFT-508	253	c-h	259	b-d	91	--	201	3.69
p	0.0029		0.03					
Mean	283		281					
LSD	161		254					
CV	33.40%		53.00%					

Summary of Intermediate Line Test Results

- Irrigated
  - 15GFT541, 511 the best yields but some variation by location
  - Yields 15% to 20% better than top varieties
  - 15GFT541 also has large seed size
- Dryland
  - Different set of accessions best - 15GFT504, HES2617
  - Yield again better than checks

Advanced Line Test - Texas and New Mexico 2018-2019

Genotype	2018L Yield lb/ac		2019L Yield lb/ac		2019C Yield lb/ac		Mean Yield lb/ac	Mean HSW g/100	2019C Disease Incidence	
15GFT-104	1591	ns	1955	a	1058	ab	1535	3.98	3.25	de
15GFT-106	1792		1891	ab	611	e-i	1431	4.23	4.00	cd
Lewis	1669		1667	a-d	942	bc	1426	3.66	3.25	de
15GFT-103	1821		932	d-g	1297	a	1350	3.71	2.25	e
15GFT-101	1957		1293	a-f	721	c-g	1324	3.97	4.00	cd
Monument	1496		1712	a-c	666	d-g	1291	3.66	4.00	cd
15GFT-105	1719		1596	a-d	551	e-j	1289	3.95	4.25	b-d
Hall	1351		1549	a-e	738	c-f	1213	3.73	3.75	d
15GFT-114	1663		1498	a-e	476	g-j	1212	3.66	4.50	b-d
Matador	1612		1235	b-f	683	d-g	1177	3.85	4.00	cd
15GFT-108	1658		965	d-g	899	b-d	1174	4.01	3.50	de
15GFT-117	1333		1296	a-f	874	b-d	1168	4.17	3.50	de
15GFT-116	1234		1616	a-d	651	d-h	1167	4.10	4.00	cd
Santa Cruz	1818		1064	c-g	535	e-j	1139	3.93	4.50	b-d
15GFT-111	1183		1706	a-c	190	kl	1026	3.82	6.00	a
Mills	1578		778	fg	192	kl	849	4.20	5.50	ab
Mean	1551		1372		602				4.26	
LSD	-		679		257				1.5	
CV (%)	27.19		30		30.2				24.9	
p-value	0.884		<0.05		<0.001				<0.001	

Oklahoma – Advanced Line Test

Genotype	2023 El Reno Yld(kg/ha)	2023 Woodward Yld(kg/ha)	2024 El Reno Yld(kg/ha)	2024 Woodward Yld(kg/ha)	Overall Mean Yld(kg/ha)	Overall Mean HSW (g/100 Sd)	Overall Mean Pct Mat Seed
15GFT-108	882	1700	1379	841	1201	2.53	73.1%
15GFT-103	818	1436	2139	293	1172	3.02	86.5%
Lewis	682	941	1840	456	980	2.95	79.4%
15GFT-111	1031	1006	1472	302	953	2.83	81.9%
Monument	853	775	1626	536	948	2.95	77.4%
15GFT-114	646	522	1464	1025	914	2.77	71.4%
15GFT-117	715	491	2025	325	889	2.79	72.0%
SantaCruz	527	731	1618	582	865	2.86	82.6%
15GFT-101	220	755	868	1405	812	2.86	57.8%
15GFT-105	719	824	998	295	709	2.98	72.6%
Matador	199	517	1683	420	705	2.79	66.9%
15GFT-116	321	515	1287	290	603	3.05	68.7%
15GFT-104	64	334	1303	328	507	2.91	62.4%
15GFT-106	356	425	502	221	376	2.77	40.6%

Advanced Line Test – Vernon, TX 2024

Advanced Test	Mean	
15GFT-108	1212	
15GFT-104	1168	
15GFT-103	1090	
Lewis	935	
15GFT-116	932	
15GFT-117	912	
15GFT-101	883	
Monument	828	
15GFT-105	812	
15GFT-111	726	
SantaCruz	721	
15GFT-106	668	
Matador	648	
15GFT-114	552	

Disease Resistance

- Major Diseases of Guar
  - Bacterial Blight
  - Alternaria Leaf Spot
- Can resistance be selected?

Source: American Phytopathological Society

Disease incidence in selected guar entries 2013 and 2014

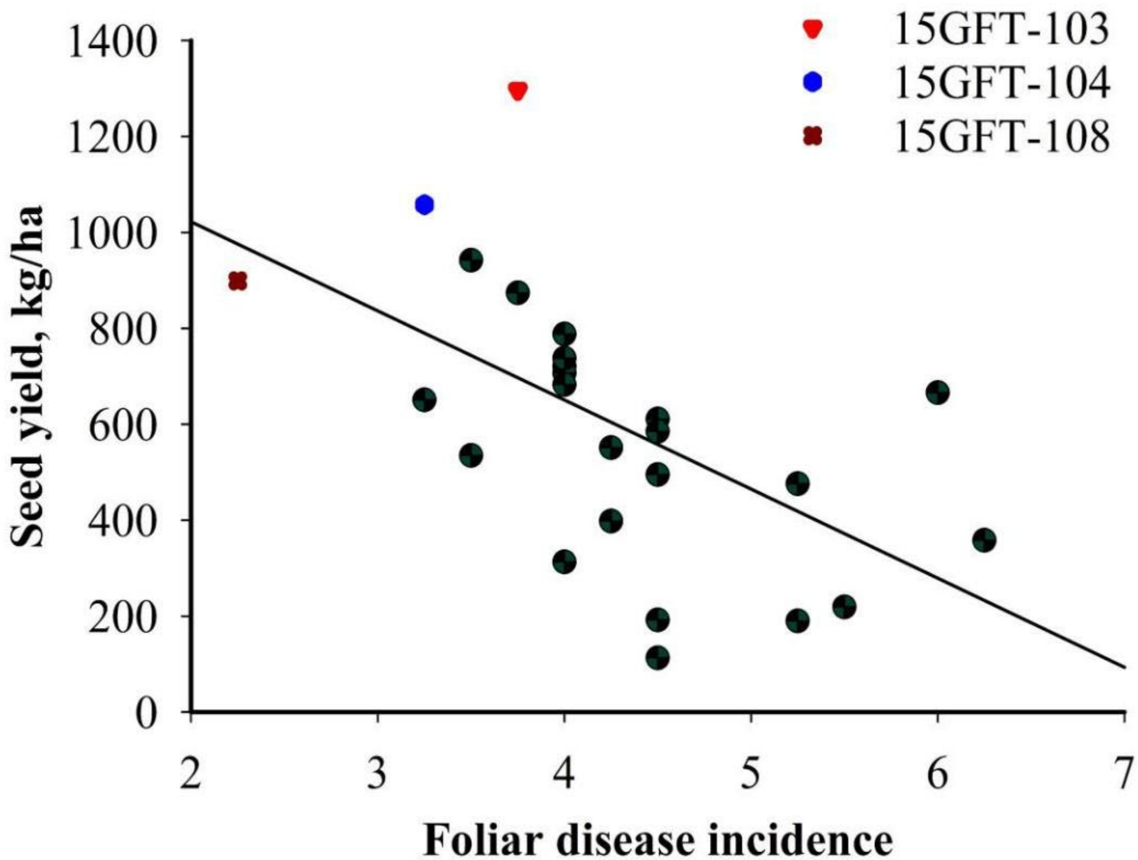
Entry	Disease Rating‡ 2013		Disease Rating‡ 2014		Seed Yield 2014		Seed Size 2014	
	--------------Rating--------------				-----kg ha-1-----		-----g 100-1-----	
TTUG-3-537-2	3.5	def†	3.3	abc†	1653	a†	3.9	ab†
TTUG-3-729-1	4.5	abc	2.4	efg	1629	a	3.2	bcd
TTUG-1401-79-3	4.7	ab	2.6	def	1617	a	3.8	ab
TTUG-3-824-2	3.7	cde	3.2	bcd	1559	ab	3.5	abc
Matador	3.7	cde	1.8	efg	1509	abc	3.0	cde
Lewis	3.3	def	1.0	g	1106	hij	3.0	cde
Kinman	2.5	fgh	1.0	g	965	ijk	3.4	bcd
TTUG-4-60-13	4.8	ab	3.0	bcd	947	ijk	3.1	cde
Santa Cruz	-		1.0	g	874	jkl	2.9	de
Monument	1.6	h	1.0	g	642	kl	2.1	e

† = Means within a column not followed by the same letter differ at the 0.05 level of probability by Student's t-test.

‡ = Disease Rating as 1.0 - Dead Plants; 2.0 - 80% Defoliation; 3.0 - 50% Defoliation; 4.0 - 20% Defoliation; 5.0 - No Symptoms.

Source: Kelby Imel, MS thesis., Texas Tech 2015

Disease Incidence and Yield - Advanced Line Test- Clovis, NM 2019.



Source: Pradip Sapkota, MS thesis., Texas Tech 2020

Summary of Advanced Line Test Results

- Disease-Free
  - 15GFT103, 104, 108 the best yielding
  - Yields 10% to 40% better than top varieties
- Disease
  - Significant negative correlation with disease
  - Top disease-free yielding accessions generally possessed disease resistance also
  - Advanced line materials more suitable for humid environments, with some irrigation

Irrigation and Profitability

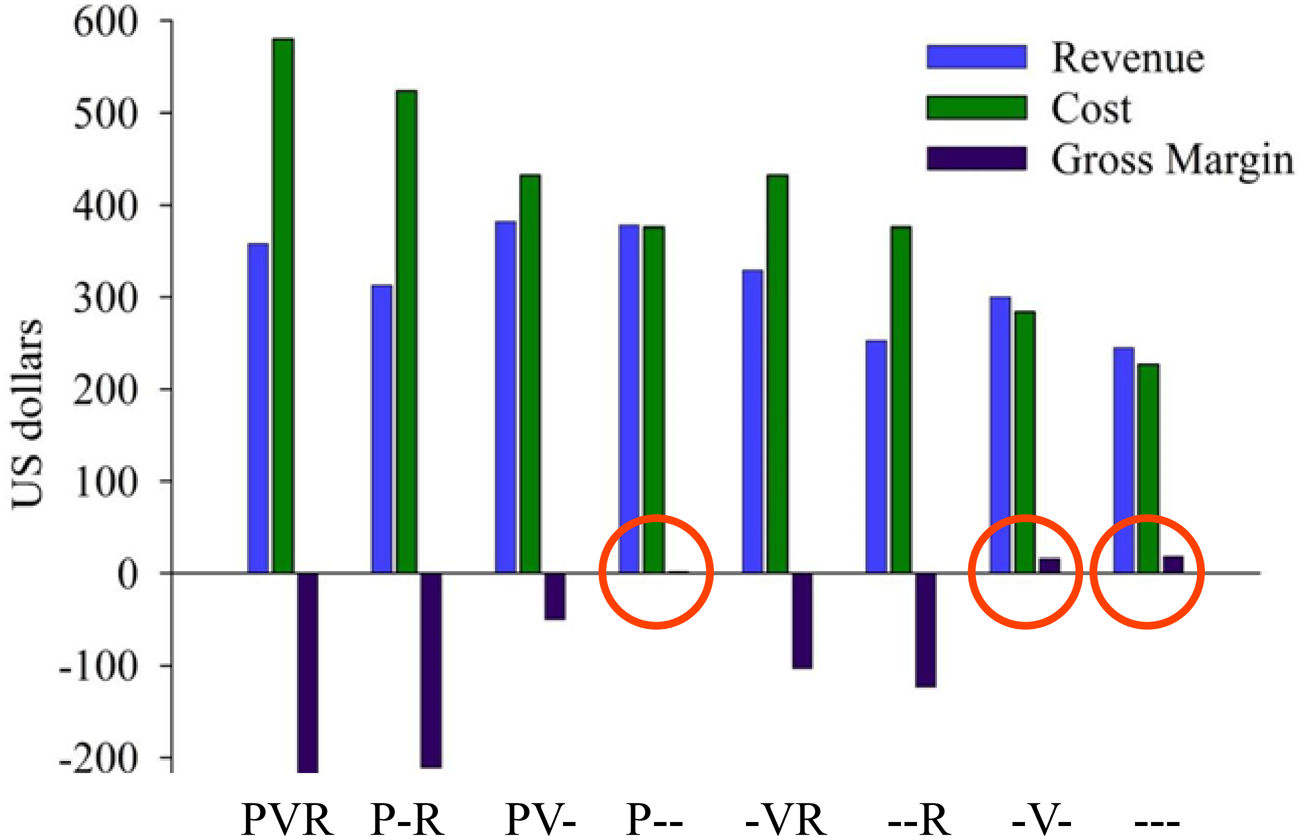
Production Cost by Irrigation Treatment- Clovis NM 2018

Treatment	Preplant (mm.)	Post-plant (mm)	Total (mm)	Common Inputs ($/ha)	Cost of water pumped ($/ha)	Total variable cost ($/ha)	Total variable cost ($/acre)
PVR	127	201	328	201	379	580	234
P-R	127	150	277	201	323	524	212
PV-	127	71	198	201	231	432	174
P--	127	23	150	201	174	376	152
-VR	0	201	201	201	231	432	174
P-R	0	150	150	201	174	376	152
PV-	0	71	71	201	83	284	114
---	0	23	23	201	26	227	91

Irrigation Treatments Applied (drip irrigation):

- P - Preplant
- V - Vegetative stage
- R - Reproductive stage
- - Not applied

Profitability by Irrigation Treatment- Clovis NM 2018



Revenue, variable cost, and profitability per hectare at the market price of $0.16/lb.

3. Forage Quality

- Potential alternative to harvest for seed yield
- What is quality of the vegetative material?
- When to harvest?
- Profitability relative to seed harvest?

Forage nutrient value for selected guar accessions

Entry	Dry Yield		Crude Protein		ADF		NDF		Total Nutrients	
	-----kg ha^{-1}-----		--------%--------		--------%--------		--------%--------		--------%--------	
Kinman	4631	a†	18.6	e†	21.4	b†	28.7	ab†	66.3	a†
TTUG-4-60-13	4347	a	19.8	cde	26.3	a	32.4	a	62.6	b
TTUG-4-24-5	4158	ab	19.5	cde	20.1	b	30.4	a	67.3	a
Matador	4040	ab	19.7	cde	22.2	ab	28.1	b	65.7	ab
TTUG-4-59-1	3969	ab	19.7	cde	25.9	ab	32.6	a	62.9	ab
Lewis	3780	ab	20.8	bcd	21.4	b	27.3	b	66.3	a
Monument	3213	b	18.6	de	26.9	a	31.7	a	62.1	b

† = Means within a column not followed by the same letter differ at the 0.05 level of probability by Student's t-test.

ADF: acid detergent fiber, NDF: neutral detergent fiber

Source: Kelby Imel, MS thesis., Texas Tech 2015

Forage Nutrient Values for Selected Accessions- Intermediate Line Test – Lubbock 2019

Genotypes	CP∞	DP	ADF	TDN	NDF
15GFT-511	21.2	16.0	22.7	65.3	31.0
15GFT-513	19.0	13.6	25.9	62.9	31.9
15GFT-521	21.2	15.7	23.7	64.6	29.3
15GFT-533	20.9	15.5	24.6	63.9	31.8
15GFT-535	20.4	14.9	24.5	64.0	30.7
15GFT-536	21.8	16.3	24.2	64.2	29.1
15GFT-537	20.4	14.9	24.2	64.2	32.0
15GFT-543	20.3	14.8	21.6	66.2	28.5
15GFT-545	22.2	16.6	24.3	64.1	30.1
Lewis	19.6	14.1	24.7	63.9	31.6
Mean	**20.7**	**15.2**	**24.0**	**64.3**	**30.6**
LSD	-	-	-	-	-
CV	5.40	6.80	6.30	1.80	7.00
p-value	0.253	0.220	0.404	0.403	0.677
Alfalfa Hay (Preston, 2015)	**19 H**		**34 L**	**61 H**	**46 L**

CP: crude protein, DP: digestible protein, ADF: acid detergent fiber, TDN: total digestible nutrient, NDF: neutral detergent fiber

Source: Pradip Sapkota, MS thesis., Texas Tech 2020

- Questions to Answer
  - Forage yield and nutrient quality ?
    - By variety
  - Multiple cuttings?
    - Number and timing
  - Can forage production be profitable?
    - By itself, vs seed production
- Planned work -
  - Timings/cuttings – Scott Logan (KSU)
  - Economic analysis – Donna McCallister (TTU/ TALR)

5. Production Functions

Crop Returns and Break Even Prices

Returns for Four Selected Irrigated Crops

Index	Cotton	Guar	Sorghum	Sesame
	---------------------$ kg^{-1}---------------------			
Price in 2017	1.43	0.35	0.15	0.62
	---------------------$ ha^{-1}---------------------			
	2508	474	951	1186
Costs	-1813	-473	-890	-808
	695	1	61	378

Break-Even Prices for Four Selected Crops

Cotton	Guar	Sorghum	Sesame	
----------------$ kg^{-1}----------------				
1.17	0.44	0.18	0.62	$0.20 /lb
0.95	0.35	0.14	0.48	$0.16
0.79	0.29	0.12	0.41	$0.13

Source: K. Imel

Sensitivity Analysis of Total Revenue by Price – Clovis 2019

Values in the boxes are revenue in $/ha; **bolded values** are the break-even price for that irrigation treatment.

$/kg	0.30	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70
¢/lb	13.6	14.5	15.4	16.3	17.2	18.1	19.1	20.0	20.9	21.8	22.7	23.6	24.5	25.4	26.3	27.2	28.1	29.0	29.9	30.8	31.8
PVR	307	327	347	368	388	409	429	450	470	491	511	532	552	573	**593**	614	634	654	675	695	716
P-R	268	286	304	321	339	357	375	393	411	429	447	465	482	500	518	**536**	554	572	590	608	626
PV-	328	350	371	393	415	**437**	459	481	503	525	546	568	590	612	634	656	678	700	722	743	765
P--	324	346	367	**389**	411	432	454	475	497	519	540	562	584	605	627	648	670	692	713	735	757
-VR	282	301	320	338	357	376	395	414	**433**	451	470	489	508	527	546	564	583	602	621	640	659
P-R	217	232	246	261	275	290	304	319	333	348	362	**377**	391	406	420	435	449	464	478	493	507
PV-	257	274	**291**	308	325	342	360	377	394	411	428	445	463	480	497	514	531	548	565	583	600
---	210	224	**238**	252	267	281	295	309	323	337	351	365	379	393	407	421	435	449	463	477	491

Sensitivity Analysis of Total Revenue by Price – Clovis 2019

- Conclusions: For the 2018 test at Clovis,
  - guar is most profitable dryland or with irrigation applied at planting
  - break-even point is 15-16c/lb
  - this was about the current price
- Additional data needed:
  - analysis at different years and locations – stability analysis
  - value of new potential varieties vs. current varieties
  - reliability of stand establishment dryland

Breeding/Varietal Conclusions

- Several breeding lines superior to checks for yield under limited irrigation or dryland
  - Guar Profitability as Seed Crop best dryland or with limited irrigation
  - Need more data across years and locations
  - Estimate benefit from expected varietal releases
  - Run preliminary increases for release
- Run preliminary increases for release
  - Forage quality apparently good but need more data on cuttings and profitability to see if is a viable alternative use for guar
- Dryland stability of production
- Economic analysis of productivity, seed vs forage

Guar Production in Texas & SW Oklahoma—Resuming in 2024

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TEXAS A&M AGRILIFE EXTENSION

Samples courtesy West Texas Guar

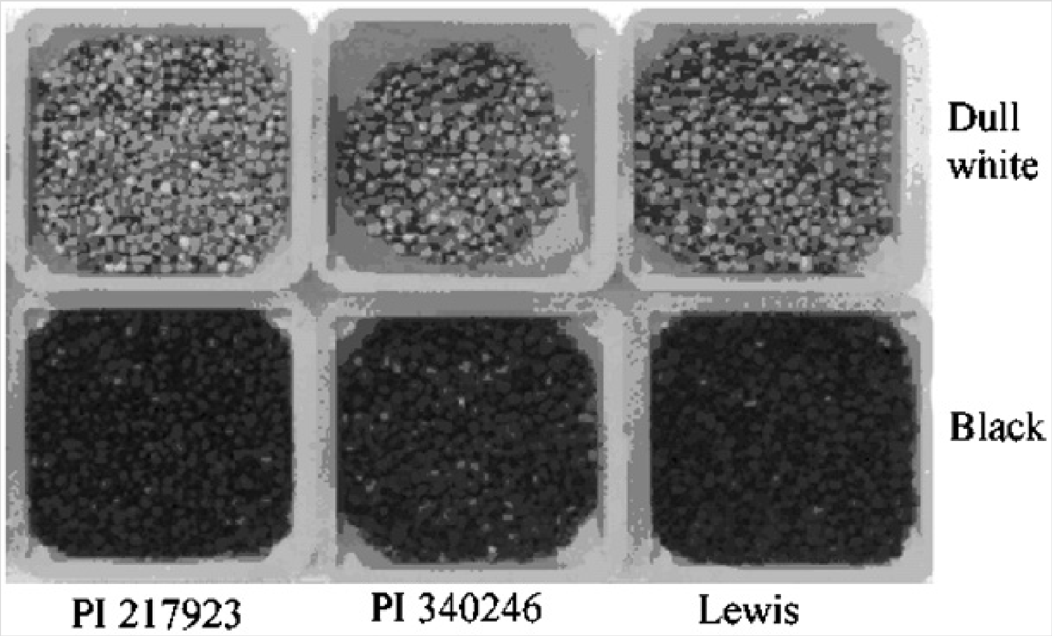
Why Guar? Why Again?

- Most heat tolerant & drought tolerant crop in West Texas (cactus anyone?)
- Many farmers:
  - Year 1, both cotton and guar in a field
  - Year 2, all cotton: “I can tell to the row where the guar was” (cotton looks better).
- “Faux” legume?

Seed Quality—Black Seed

Texas Tech Univ. research on black seed—often assumed to be of inferior quality

Germination is higher in black seed (degradation of seed coat, better water uptake), but endosperm content was not significantly different—gum reported colored seeds.



Journal of Arid Environments 70 (2007) 29–38.

Guar Grain Grading Schedule

(punitive)

Test Wt. (lbs./bu)3	Seed Color (50%)	Grade	Price ($/cwt.)
>60.0	Light	1	Full
>60.0	Dark	2	-10%
59s	Light	3	-20%
59s	Dark	4	-30%
58s	Light	5	-40%
58s	Dark	6	-50%
<57.0	N/S	7	-75%

Preliminary—2024 Lubbock Dryland

Planting Date	Test Wt. (lbs./bu)	%Black Seed	%Shriveled Seed
5/8	59.1	3.3	8.7
5/24	59.9	2.7	6.6
6/11	59.4	2.2	6.7
6/28	60.3	4.2	6.5
7/15	54.3	4.3	5.2
P-Value	0.03	0.04	0.22

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