SUSTAINABLE BIOECONOMY FOR ARID REGIONS (SBAR)

Summary Report – Quarter 2, 2020

Information submitted by project partners; synthesized by:
Alix Rogstad, Project Director of Operations

USDA Cover Page

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Name of Submitting Official	*Signature / Date*

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INTRODUCTION AND MANAGEMENT

General Overview: Organization

The Sustainable Bio-economy for Arid Regions (SBAR) Center of Excellence continues to succeed under the tutelage of Dr. Kimberly Ogden, who leads the overall research effort and ensures adequate progress toward meeting goals. The SBAR Project Director (Alix Rogstad) continues to oversee operations and manage all of the day-to-day project administration and business affairs, as well as coordination, communication, and data sharing among partnering organizations and institutions.

A comprehensive project evaluation plan, approved in July 2018, is still effectively capturing detailed progress on the project's defined objectives. As a living document, the evaluation plan will change to reflect revised research questions, project goals and big-picture, overall objectives. The second-year comprehensive review for the project was conducted at the 2019 SBAR Retreat in September, and lessons learned and feedback are being incorporated into year three activities. The next scheduled thorough review and update will be in July 2020.

Advisory Board

No changes were made to the Advisory Board makeup during this quarter (Table 1).

Table 1. *SBAR Advisory Board members.*

Advisory Board Member	Company/ Representation	Year Joined Board
Chris Cassidy	USDA, Rural Development	2018
Matt Chavez	Independent Grower, NM	2017
Steve Csonka	Commercial Aviation Alternative Fuels Initiative (CAAFI)	2017
Mark DeDecker	Bridgestone Americas, Inc.	2017
Gary Deen	Double D Farms, AZ	2017
William Goldner	USDA, National Institute of Food and Agriculture	2017
John Holladay	Pacific Northwest National Laboratory	2019
Chris Kuzdas	Environmental Defense Fund	2018
Homer Marks	Southwest Indian Agriculture Association, Tohono O'odham Nation	2017
Newt McCarty	NMSU, Extension Educator	2018
Jaroy Moore	Texas A&M Agrilife Research & Extension Center	2017
Alex Muravijov	Guar Resources	2017
Paul "Paco" Ollerton	Tierra Verde Farms, AZ	2019
Matt Payne	West Water Research, Inc.	2018
Bob White	Bridgestone Americas, Inc.	2017

Receiving the signed non-disclosure agreements (NDA) to ensure confidentiality of research data, information, and conclusions for the duration of the project remains ongoing. To date 7

NDAs have been completed and returned, 4 other Advisory Board members are subject to existing project NDA and confidentiality agreements, and the remaining 4 NDAs are pending. Sensitive data is not shared with individuals until a signed NDA is on file.

The Advisory Board meets frequently (4 times/year) so that (1) relevant research updates can be shared; (2) Advisors can drill down into specific Component work as it is underway; and (3) the researchers can solicit comments/suggestions for improving research direction or overcoming challenges. Ultimately, the goal for more frequent meetings is to ensure that SBAR can remain agile in addressing changing priorities and circumstances.

The Advisory Board met in April, where the Characterizations & Co-Products Team provided an overview and status update on the research progress. A second meeting was hosted this quarter in May, where the Extension & Outreach and Education Teams provided a synopsis of progress made with growers and changes required for project implementation as a result of the COVID-19 pandemic. During both meetings, the Advisory Board members were able to learn more about on-going processes and plans, and they could ask direct questions to the team members regarding outreach activities and youth education using SBAR-generated curriculum.

A future Advisory Board meeting will be hosted during the 2020 SBAR Retreat planned for July 2020.

Budget and Financial Management

Budget management activities continue to work effectively, and all project expenditures are on track. Rogstad continued to maintain sub-award agreements and develop modifications when necessary, non-disclosure agreements, and work with partners to ensure grant funds are spent according to the project plan and approved scopes of work.

An expenditure issue arose this quarter because a researcher at New Mexico State University used allocated research funds in an unapproved manner to purchase field equipment. The issue was eventually resolved, but clear steps have now been identified for preventing future expenditures of this nature.

Sub-awards are fully activated with all project partner institutions: Bridgestone Americas, Inc., New Mexico State University (NMSU), Colorado School of Mines (CSM), Colorado State University (CSU), and the USDA-Agricultural Research Service (USDA-ARS). All sub-awards are progressing appropriately.

Component Working Group Meetings

All five SBAR component working groups continued to participate in scheduled online meetings to ensure forward momentum on all project tasks. Smaller focus group meetings were scheduled and facilitated as necessary, including budget meetings and partnership development meetings. During this reporting period, the virtual meeting space (via Zoom) was utilized 63 times for over 58.5 hours. As the COVID-19 pandemic required closures during this quarter, SBAR work shifted to virtual platforms like Zoom, which showed a marked increase in the number of Zoom participants from previous quarters with at least 614 individuals accessing meetings. An additional 3 meetings were hosted during the same timeframe that did not require the virtual meeting space.

LEADS Team Meetings

The component leaders and co-leaders (LEADS) continued to meet with Ogden and Rogstad during established twice-monthly meetings held via SBAR's dedicated Zoom online meeting space. The LEADS continue to provide guidance for project decisions, and assist with resolving internal conflicts that are brought for discussion. This has proven to be an effective way to communicate key issues requiring short turn-around times.

As mentioned above (*Budget and Financial Management*), the LEADS discussed unapproved budget expenditures this quarter and made preliminary decisions about the Year 4 budget cycle.

SBAR Annual Retreat

Due to the COVID-19 pandemic, the decision was made in mid-June to shift the 2020 SBAR Annual Retreat to a virtual platform. The Retreat dates remain the same (27-29 July), but the agenda will undergo major modifications to reduce Zoom fatigue. As previous years, the 2020 SBAR Annual Retreat will be hosted by the University of Arizona. The Retreat will include updates from industry partners and visionaries, research highlights for each Component, Advisory Board meeting time, and open networking periods. Although no poster session will be hosted, there will be opportunities for online networking during "breaks," and there will be Component working sessions on the last day. Agenda materials will be provided in the next quarterly report.

Communication and Reporting

Rogstad continues to be the main point-of-contact for most SBAR communication. Various listservs are maintained that enable quick dissemination of pertinent and critical information. Rogstad also fields questions and liaises among project researchers, Advisors, partners, and students.

Reporting schedules for researchers are established and working well. Quarterly reports submitted are synthesized and made available to the research team and Advisory Board members. Summary reports are also posted to the SBAR website for wider dissemination. Each researcher is required to submit a self-evaluation score/rank with their report, and they are asked to describe all issues that may put them at risk for meeting annual goals (as articulated in annual scopes of work). A Task Tracker Report is provided to the LEADS, which gives a status update for each team member per component. The Task Tracker Report is a proactive management tool that allows the identification of issues before they become risks for overall project completion.

Website and Social Media

The SBAR-specific website (www.sbar.arizona.edu) continues to be regularly updated and maintained, serving as the digital "face" of the SBAR Center. Updates this quarter included project highlights that showcased new work, and materials associated with the 2020 SBAR Virtual Retreat. The Extension & Outreach pages – including the Grower-focused pages and the Youth Development page – are also currently under revision.

The SBAR webpage was visited by people in 41 different states of the USA during this reporting period (Table 2). Visits from four new states (Alabama, Connecticut, New Jersey and Rhode

Island) occurred this quarter. Since inception, the website has been viewed by people in 48 states, which is an indication of wide interest in the ongoing research as well as the broad dissemination of information implemented by project partners.

Table 2. *Web traffic to the SBAR Center webpage from within the United States since inception.*

	Time Period				
State	**Jul – Dec 2018**	**Jan – Dec 2019**	**Jan – Mar 2020**	**Apr – Jun 2020**	**Jul – Sep 2020**
Alabama				X	
Arizona	X	X	X	X	
Arkansas		X	X		
California	X	X	X	X	
Colorado	X	X	X	X	
Connecticut				X	
Delaware		X	X		
District of Columbia	X	X	X	X	
Florida		X	X	X	
Georgia		X	X	X	
Hawaii			X		
Idaho		X	X	X	
Illinois	X	X	X	X	
Indiana		X	X		
Iowa	X	X	X	X	
Kansas	X	X	X	X	
Kentucky		X	X	X	
Louisiana			X	X	
Maine			X		
Maryland	X	X	X	X	
Massachusetts		X	X	X	
Michigan		X	X	X	
Minnesota		X	X	X	
Mississippi		X	X	X	
Missouri		X	X	X	
Montana		X	X	X	
Nebraska		X	X	X	
Nevada		X	X	X	
New Jersey				X	
New Mexico	X	X	X	X	
New York	X	X	X	X	
North Carolina	X	X	X	X	
North Dakota		X		X	
Ohio		X	X	X	
Oklahoma		X	X		
Oregon		X	X	X	
Pennsylvania		X	X	X	
Rhode Island				X	
South Carolina	X	X	X	X	

	Time Period				
State	**Jul – Dec 2018**	**Jan – Dec 2019**	**Jan – Mar 2020**	**Apr – Jun 2020**	**Jul – Sep 2020**
South Dakota		X		X	
Tennessee	X	X	X	X	
Texas	X	X	X	X	
Utah		X	X	X	
Virginia		X	X	X	
Washington	X	X	X	X	
West Virginia		X			
Wisconsin		X		X	
Wyoming		X	X	X	
Total	**15**	**41**	**40**	**41**	

There were 2,576 unique sessions from April – June 2020. This is a 192% increase from the previous quarter. Page views occurred in 32 different countries this quarter (top three: USA, China, and The Netherlands), including 7 countries that have not visited the website previously (Belize, Cameroon, Jordan, Norway, Oman, Serbia, and Uganda). Visitors from the USA account for about 96% of site visits during this reporting period. This quarter showed an increase in website visits from Asian countries (China, India and Japan), which accounted for another 2% of site visits overall.

There have been 8,703 unique website sessions since July 2018. Since activation, the website has had visitors from 6 continents and 79 different countries around the world (Table 3). The highest visited website pages during this period included those that describe our team and partnerships, define our project objectives, and those associated with the 2020 SBAR Virtual Retreat. Other highly visited pages included those that provide details about ongoing research and those that provide educational resources. The website will continue to be updated regularly as the project unfolds.

Table 3. *International web traffic to the SBAR Center webpage since inception.*

Country	**Time Period**				
	Jul – Dec 2018	**Jan – Dec 2019**	**Jan – Mar 2020**	**Apr – Jun 2020**	**Jul – Sep 2020**
Algeria			X		
Argentina		X			
Australia	X	X	X		
Austria	X	X	X	X	
Bahrain			X		
Bangladesh		X	X	X	
Belgium		X		X	
Belize				X	
Brazil		X		X	
Cameroon				X	
Canada	X	X	X	X	
Chile		X			

Country	Time Period				
	Jul – Dec 2018	Jan – Dec 2019	Jan – Mar 2020	Apr – Jun 2020	Jul – Sep 2020
China	X	X	X	X	
Colombia		X	X		
Congo-Kinshasa		X			
Côte d'Ivoire		X		X	
Cyprus		X			
Ecuador			X	X	
Egypt	X				
Estonia		X			
Ethiopia	X				
Finland			X	X	
France		X	X	X	
Germany	X	X	X	X	
Ghana		X	X	X	
Grenada			X		
Greece			X		
Honduras		X			
Hong Kong	X	X			
Hungary			X		
India	X	X	X	X	
Indonesia		X			
Iran	X	X	X	X	
Ireland		X			
Israel		X			
Italy	X	X	X	X	
Japan	X	X	X	X	
Jordan				X	
Kenya		X			
Kuwait	X	X			
Lebanon		X			
Malaysia		X			
Mexico	X	X	X	X	
Morocco		X			
Namibia		X			
Nepal	X	X		X	
Netherlands		X	X	X	
New Zealand	X		X		
Nigeria		X	X	X	
Norway				X	
Oman				X	
Pakistan	X	X	X	X	
Paraguay		X			
Peru		X			
Philippines	X	X	X		
Poland		X	X		
Portugal		X			
Qatar		X	X		

Country	Time Period				
	Jul – Dec 2018	Jan – Dec 2019	Jan – Mar 2020	Apr – Jun 2020	Jul – Sep 2020
Romania			X		
Russia		X			
Saudi Arabia		X	X		
Serbia				X	
Singapore		X			
South Africa		X			
South Korea		X	X	X	
Spain		X			
Sri Lanka		X			
Sweden		X			
Switzerland			X	X	
Taiwan		X			
Thailand	X	X	X		
Turkey	X	X	X	X	
Uganda				X	
Ukraine		X			
United Arab Emirates		X			
United Kingdom	X	X	X		
United States	X	X	X	X	
Vietnam		X			
Zambia		X			
Total	**22**	**60**	**36**	**32**	

FEEDSTOCK DEVELOPMENT & PRODUCTION

Project Coordination: The Feedstock Development (FD) Team holds a single joint monthly meeting and periodically meets on an as-needed basis in between monthly meetings. The UA continues to lead these meetings (Dr. Dennis Ray), which are leveraged to ensure all team members are on schedule and research work can seamlessly integrate between components. Questions related to planting or harvesting schedules are generally worked out during these monthly meetings. The FD team members also meet during weekly research team meetings (all-hands) hosted at both the UA and New Mexico State University. These weekly briefings provide an opportunity for open communication regarding on-going experiments, issues/challenges, and results for both guayule and guar research. Quarterly summary reports also provide an opportunity to discuss relevant research topics and questions that may need further exploration.

Issues/Risks:

Abdel-Haleem: Due to global COVID-19 pandemic situation and USDA policies of essential operations and maximum teleworking, dried guayule samples from each plot are stored at -18C to preserve and HTP scanning data were collected awaiting the situation for final analyses, based on the current situation, it is early to predict if 2020 milestones will be met.

Angadi: Pandemic of COVID-19 has affected our research activities. Although I obtained approval from NMSU to conduct most of our guar field projects, restrictions are there on movement, hiring new people, participation of people, etc. Remote sensing observations may have problems. Incubator study to assess guar germplasm was not started and hope new graduate student will start, when he joins the program.

Dierig: Bridgestone Agro Operations partially shut down as a result of COVID-19 response. We anticipate to still meet the goals of our SOW. We completed most of the harvesting and processing of shrubs prior to shut-down. The analytics will be slightly delayed.

Grover: Due to the current COVID-19 lockdown, the research work and sample processing was paused and was resumed later in the quarter after the approval was obtained from the NMSU VPR's office. A new thresher was acquired and threshing of guar plant samples is in process to obtain the seed yields.

McCloskey: The SARS-COV2 virus and the failure of the fall 2019 preemergence herbicide experiments caused some delays. However, I am optimistic that the herbicide registrations can be obtained in 2020.

McMahan: The USDA-ARS-WRRC location of the research was shut down in response to the COVID-19 pandemic on March 17, 2020. Essential operations (preservation of plant and animal life and safety) continues but all other work has been moved to telework. We are fortunate to have skilled employees (Mariano Resendiz, Grisel Ponciano, Kumi Johnson) supporting preservations of SBAR project plant cultures. However, new transformations, and genotype/phenotype evaluations, have been discontinued. Therefore, ASE testing (Deliverable #2) did not take place.

In addition, we have not been able to regenerate sufficient tissue culture plants to move a set to the greenhouse. However, this work is considered Essential, and we anticipate having plants from at least one construct moved to the greenhouse by 3Q2020.

Neilson/Maier: Research progress has been constrained during Q2 due to restricted lab access as a result of the coronavirus. Some tasks have not advanced due to the fact that students can't get into the labs to do the work. The analytical lab used for soil texture analysis as described is still closed. The work will be completed as soon as the university opens the Shantz Building to general access. Other tasks are now in progress again after a short hiatus. We have been granted a waiver to have one graduate student continue with extracting the DNA from the Eloy soils sampled in 2019. When this task is completed, he will begin working on other tasks that have been put on hold.

Similarly, tasks associated with the soil microbiome network analysis have not been completed because access to the Bio5 research lab was not available. As described above, the lab was recently opened and work on the DNA extractions began again on July 10th. There are 240 samples to be extracted and it is anticipated that this work will take one month to complete.

Ogden: COVID19 Issues – AquaCrop activities: the graduate student working on this part of the project has had many issues related to COVID and his family so the work is not progressing in a timely manner. Hopefully, he will complete his MS in the next quarter. BioCrop activities: the university is back open to a limited degree and we are progressing on more characterization studies but it is slow. Bridgestone is now reopened to do analysis, but they have had some maintenance issues that should be solved soon so that we can more strategically plan the next phase of the distillation experiments.

Ray: Many experiments were/are on hold due to the pandemic. Work is progressing slowly and safely.

Objective 1. Improve biomass quantity and quality through genetics and traditional breeding.

Task #	Description of Task	Deliverable	Target Completion Date
1 Dierig	Evaluate USDA germplasm lines	Ploidy analysis completed Harvest/Analysis of first growth cycle completed	31 Aug 19 30 Apr 22
2 McMah	Perform plant transformations using all 3 constructs (AP1, SEP3, FT, LEAFY)	Confirmed transformation for invitro plants – 6 lines AP1 Confirmed transformation for invitro plants – 6 lines SEP3 Confirmed transformation for invitro plants – 6 lines FT	31 Aug 20 31 Aug 20 31 Aug 20

		Confirmed transformation for invitro plants – 6 lines LEAFY	31 Aug 20
3 McMah	Determine effect of transgenes on rubber content by ASE (tissue culture)	% rubber data obtained for each construct line	31 Aug 20
4 McMah	Transfer plants to greenhouse for flowering phenotype	Transfer at least 2 lines to greenhouse	31 Aug 20
5 Ray	Evaluate growth and rubber/resin content in guayule germplasm lines	Rubber/resin content determined in 21 guayule germplasm lines	30 Jun 20
6 Ray	Compare root growth/architecture and water use in direct-seeded and transplant-established guayule	Plantings established Compare root growth and top growth for direct-seeded and transplant-established plants Compare root growth/top growth/water use	31 Jan 20 31 May 20 31 Mar 20

Evaluate Germplasm Lines (Variety Trials):
Two trials planted by direct seeding at Eloy, April and May 2018 were harvested in March, 2020. The first trial includes 55 USDA varieties and the second 30 varieties, both with 4 replications. One-m2 section was harvested from each plot. The same trial was planted in Maricopa, AZ and harvested at the same time. Rubber and resin analysis of both locations is in progress and results will be included along with biomass and rubber yield data in the 2020 Q3 report.

Plant Transformations using AP1, SEP3, and FT Genes:
Our project seeks to enhance natural rubber content in guayule by downregulation of flowering. Previously, four target genes (*APETALA1, SEPATTALA3, FLOWERING TERMINUS, LEAFY)* all transcription factors related to flowering, were identified. Five guayule transformation constructs for downregulation (including one 2-gene version: *pND6 – AP1 – SEP3 (pAS))* were prepared and plant transformations performed.

In 2Q20, we focused on transformations of *pAS* constructs and on recovery of plants from the other 4 constructs. Shoot regeneration issues have continued to plague AP1 and pAS (AP1 + SEP3) constructs. It is possible that the AP1 gene downregulation may interfere with shoot development. For example, in July 2020, we have 200 calli with the Leafy construct and 0 calli with the pAS construct. We will try one final round of pAS transformations with media optimized for osmotic potential (Zhou H, Zheng Y, Konzak CF. Osmotic potential of media affecting green plant percentage in wheat anther culture. Plant Cell Rep. 1991;10(2):63-66. doi:10.1007/BF00236458).

We have successfully obtained shoots from the other 3 constructs (SEP3, FT2, LEAFY) and roots in some cases.

Table 4. *Status of transformed plant recovery July 15, 2020.*

Construct	**Calli Status**	**Plants recovered**	**PCR results**
APETALA1 AP1	Calli growing under selection pressure.	-	-

SEPATTALA SEP3	Calli growing under selection pressure.	205 plants moved to rooting media.	Plant transformation confirmed by PCR for 6/6 events.
FLOWERING LOCUS T FT2	Calli growing under selection pressure.	2 plants successfully rooting	Pending
LEAFY	Calli growing and forming leaves under selection pressure.	3 plants successfully rooting	Pending
pND6 – AP1 – SEP3 (pAS).	Initial calli obtained, transformations continuing.	-	-

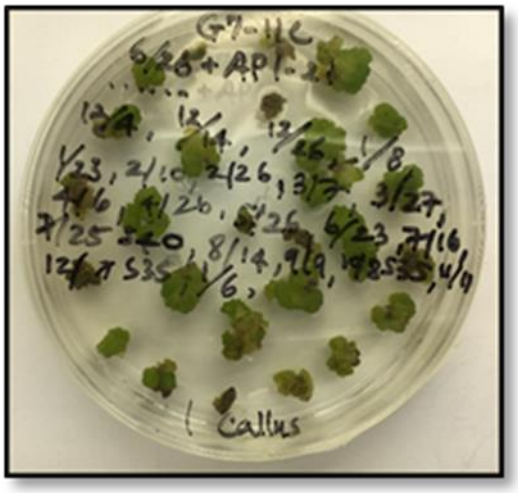

Figure 1. *Calli growing under selection pressure for APETALA1 (AP1).*

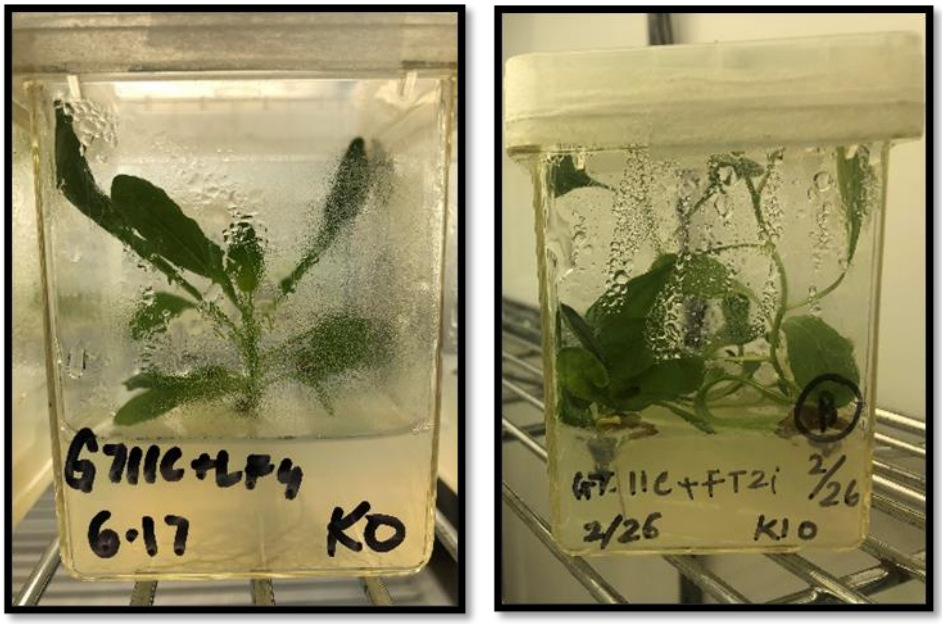

Figure 2. *LEAFY and FT2 plants with developed shoots ready for PCR testing.*

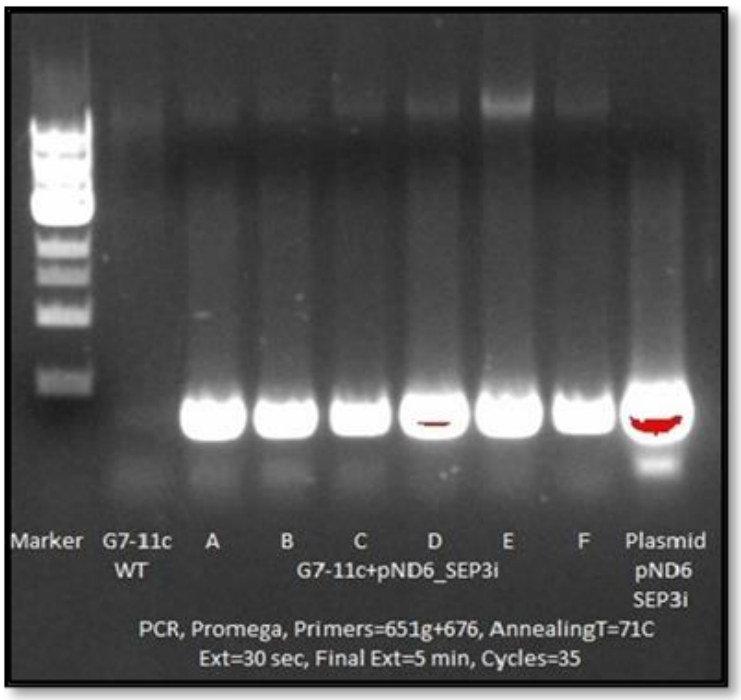

Figure 3. *PCR results for SEPATTALA (SEP3).*

Effect of transgenes on rubber content by ASE (tissue culture):
Research continues as planned; no data to report.

Transfer plants to greenhouse for flowering phenotype:
Research continues as planned; no data to report.

Growth and Rubber/Resin Content in Guayule Germplasm Lines:
Plant samples that were harvested and processed last quarter (25 February) are being analyzed by Acclerated Solvent Extraction (ASE) for resin and rubber to compare with the same samples harvested in fall 2019.

Root Growth/Architecture Compared to Water Use in Direct Seed and Transplant-Established:
Roots that were harvested 9 November (185 DAP) and 20 December (226 DAP) were analyzed for resin and rubber (Table 5).

Table 5. *Mean values for "resin" (acetone-extractables) and "rubber" (cyclohexane-extractables) in guayule plant material (AGB= above ground biomass and roots found in the first 20cm) harvested at 185 and 226 days after planting. Values in a column marked with * are significantly different.*

	RESIN %				RUBBER %			
	AGB		0-20 cm roots		AGB		0-20 cm roots	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
185 DAP								
Direct seeded (n=4)	5.85	1.74	3.50	1.92	2.30	0.47	0.85*	0.29
Transplanted (n=4)	4.73	2.13	3.33	1.79	0.85	0.29	1.79*	0.41
226 DAP								
Direct seeded (n=4)	9.28	1.53	7.21	1.87	2.40	0.22	1.42	0.40
Transplanted (n=4)	8.26	0.78	5.02	1.10	2.32	0.16	2.07	1.04

Objective 2. Develop high-throughput phenotyping to support crop expansion using remote-sensing methods to create interactive databases/tools.

Task #	Description of Task	Deliverable	Target Completion Date
1 Abdel-H	Phenotypic characterization - Guayule	Collect and analyze available phenotypic data; plant stand and establishment, plant height and width, flowering time, rubber, resin	31 Dec 21
		Collect and analyze first set of available high-throughput phenotyping (HTP) parameters: vegetation indices and reflectance	31 Dec 21
		Summary report completed	30 Jun 22
2 Abdel-H.	Phenotypic characterization – Guayule under stress conditions and stability	Field planting – plant and maintain USDA guayule collections	30 Jun 20
		Collect and analyze available phenotypic data: plant ht, plant width, flowering time, rubber, resin	31 Dec 21
		Collect and analyze available high-throughput phenotyping (HTP) parameters: vegetation indexes and reflectance	31 Dec 21

		Summary report completed	30 Jun 22
3 Abdel-H	Guayule leaf waxes	Leaf wax extraction from guayule tissue Wax class determination Summary report completed	31 Jan 21 31 Dec 21 31 Jan 22
4 Angadi	Guar remote sensing	Seasonal multispectral data from deficit irrigation study	31 Mar 20
5 Dierig	Remote sensing evaluation of USDA germplasm lines	Rate of growth comparison between lines completed	31 Aug 20

Phenotypic characterization – Guayule:
Second year of the field trial containing 48 USDA guayule accessions are maintained at Maricopa, AZ. Plots are maintained by hand weeding as needed and surface irrigation at bi-weekly internal based on the weather and plant growth stage.

Two-year old guayule shrubs were harvested, air-dried and are stored at -18C due to global COVID-19 pandemic situation and USDA policies of minimum essential operations at USDA-ALARC facility and maximum teleworking. As situation is relaxed, samples are being chipped and ground and final ground samples will be transferred to Eloy station for rubber and resin contents using NIRS models. Preliminary results are available for dry biomass of the two years' of growth.

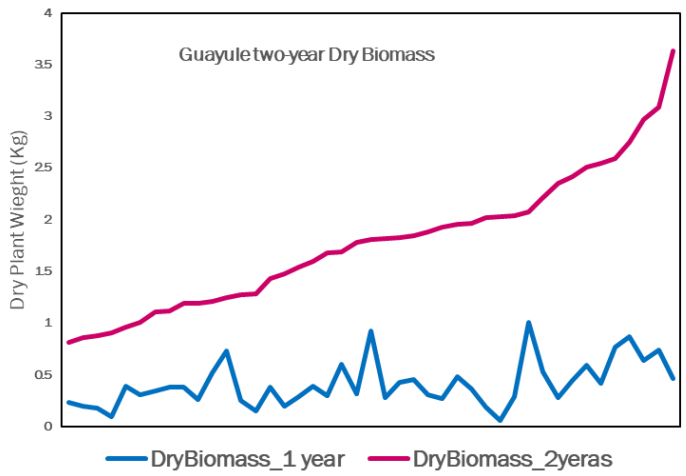

Figure 4. *Preliminary results of the dry biomass (wt) of guayule grown at the Maricopa Agricultural Center, Maricopa, Arizona.*

Due to current situation, weekly HTP runs are started and data are collected and stored at ALARC servers awaiting analysis due to COVID-19 situation.

Phenotypic characterization – Guayule Under Stress Conditions:
A new experiment with 60 guayule genotypes, including new genotypes that will be tested for the first time, and 6 common checks has been initiated at Maricopa, AZ with the target to test guayule genotypes growing under stress and non-stress conditions.

Differential irrigation schedules were started at stress and non-stress treatments. At both trials, plots are maintained by hand weeding as needed.

Due to global COVID-19 pandemic situation and USDA policies of minimum essential operations at USDA-ALARC facility and maximum teleworking, HTP scans for traits including canopy temperature, plant height and vegetation indexes are started and collected data are stored at ALRAC servers awaiting final analysis.

Preliminarily analyses of HTP data showed that guayule growth is higher under well-watered condition compare to reduced-water condition, as well within stress conditions there are differential responses among guayule genotypes suggesting high genetic variability in drought tolerance among USDA guayule collection.

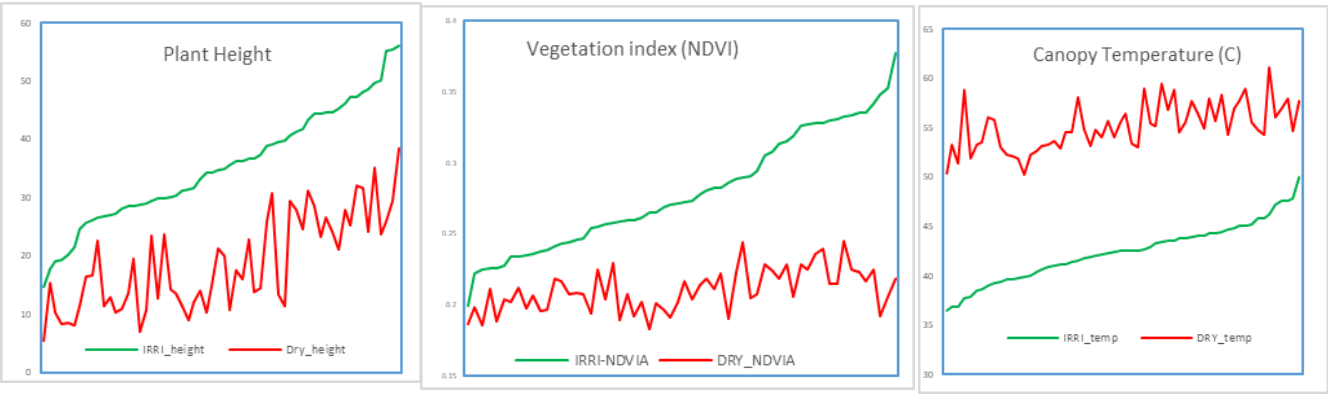

Figure 5. *Preliminary HTP analysis for guayule plants at the Maricopa Agricultural Center, Maricopa, Arizona.*

Guayule Leaf Waxes:
SBAR-supported experiments for leaf waxes in guayule were halted. No further data will be reported.

Guar Remote Sensing:
Due to COVID-19, Dr. Diaa El-Shikha will not be traveling to Clovis, NM to fly drones to collect remote sensing data. Effort to find some money to buy drones and sensors for Clovis, NM has not been successful. Nearby USDA-ARS offices in Texas are closed due to the pandemic. We are talking to a few NMSU researchers to help with it. This data will be very useful for Hadiqa Maqsood's research work.

Remote Sensing Evaluation of USDA Guayule Germplasm Lines:
Research is continuing as planned; no new data to report.

Objective 3. Deploy superior genotypes of guayule and guar to regional growers.

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Evaluate guar germplasm in New Mexico high plains environment	Identify guar germplasm suitable for cooler and northern latitudes	30 Apr 20
		Summarize data after harvest; present at field day in Clovis, NM	31 Dec 19
		Assess available guar cultivars at Clovis, NM	31 Dec 19
2 Angadi	Galactomannan assay	Assess irrigation effect on guar gum content	30 Apr 20
3 Grover	Evaluate guar germplasm lines (increase # of seeds)	Collect data on field performance of guar germplasm lines	31 Aug 20
		Generate report on guar germplasm line field performance	31 Aug 20
4 Ray	Evaluate seed from plants surviving root rot inoculation	Screen 42 guayule germplasm lines for root rot fungus tolerance	31 Jan 20
	Determine root rot tolerance per guayule germplasm	New germplasm lines screened for the first time	30 Nov 20
		Seed from surviving plants screened for trait inheritance	31 Dec 21
5 Ray	Guayule salt tolerance trials	7 germplasm line's transplants evaluated for sensitivity under 11 saline treatments	31 Dec 19
		Initial estimate of lines with most tolerance complete	31 Dec 19
		Continue screening germplasm lines	31 Aug 20
		Seed from surviving plants collected and planted for 2nd round evaluation	31 Oct 20
6 Ray	Guar yield trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM	Increase guar seed for yield tests	15 Apr 19
		Yield trial protocols established (3 different for comparison)	1 May 19
		Yield trials planted in 3 locations	30 Jun 20
			31 Dec 20

		Yield trials harvested; yields compared	
7 Ray	Guar genetic combination trials	Guar seed from crosses of partial male-sterile plants with 2 elite lines collected Genetic diversity evaluated	31 Dec 19 31 Jan 21

Guar Germplasm in New Mexico:
We have initiated all field trials and the crop is looking good instead of extremely dry and hot summer. The Pandemic COVID-19 is restricting many research activities and hiring of technician and graduate student. However, with special permission from Vice-president Research of NMSU, we are conducting all field trials.

USDA guar germplasm trial was planted again this year. Due to late arrival of seeds, the trial was planted in the middle of June. Emergence and seedling growths are looking good.

Guar Galactomannan Assay:
Galactomannan assay was completed on 2018 samples from deficit irrigation trial to assess the effect of levels of water availability on galactomannan content of guar seeds. Assay underestimated galactomannan content and repeated attempts to modify protocol and talking to company developing assay did not correct it. We are storing the sample to retry after the problem with assay kit or protocol is addressed. In spite of low gum yields, irrigated guar seeds had higher gum content. Results were reported in Jagdeep Singh's thesis and this work is complete.

Guar Germplasm Line Multiplication:
Data compiled and analyzed for evaluating guar germplasm for biomass, yield attributing characteristics from 2019 growth season at Las Cruces, NM. Results are being summarized.

Genotypes PI 268629, PI 338811 and PI 126152 produced the highest above ground biomass (6,857-7,367 Kg/ha) while genotypes PI 253186, PI 5993049 recorded the lowest amounts of biomass (4,207-4,650 Kg/ha) (Figure 6).

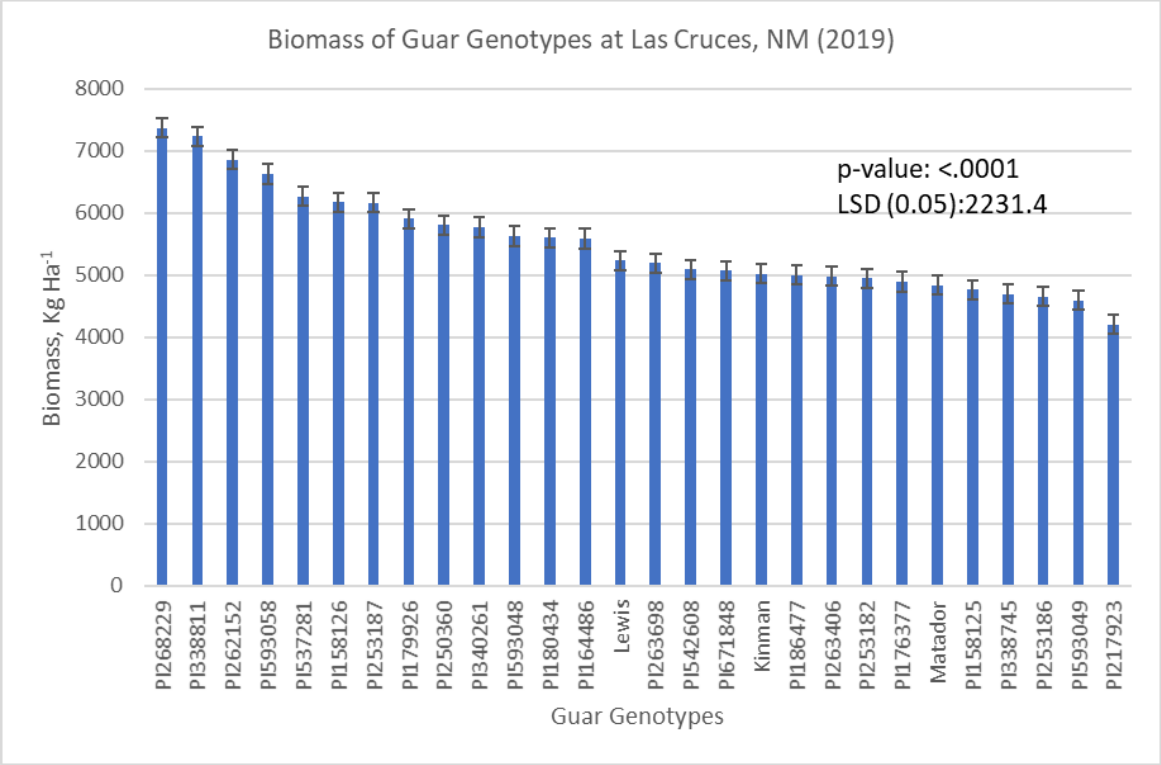

Figure 6. *Biomass (kg/ha) of guar genotypes at Fabian Garcia Plant Science Center, Las Cruces, New Mexico (2019).*

PI 217923, PI 253182 and PI 186477 had the highest harvest index among the genotypes (Figure 7).

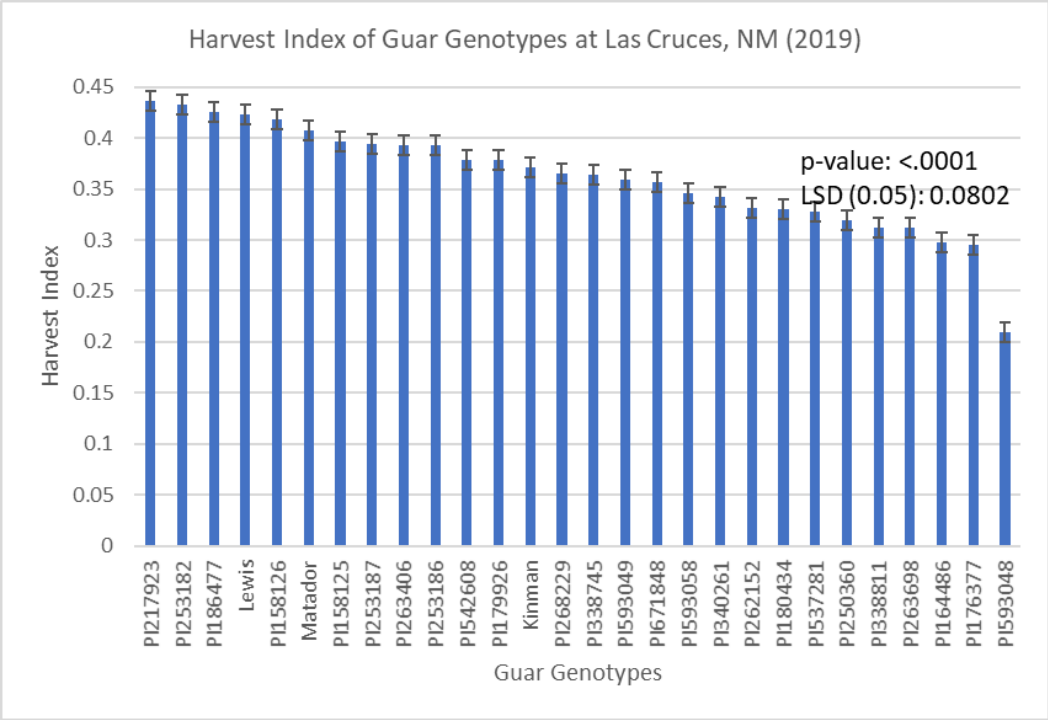

Figure 7. *Harvest index of guar genotypes at Fabian Plant Science Center, Las Cruces, New Mexico (2019).*

PI268229 had the highest seed yield followed by PI158126 and PI253187although the differences were not significant among genotypes (Figure 8).

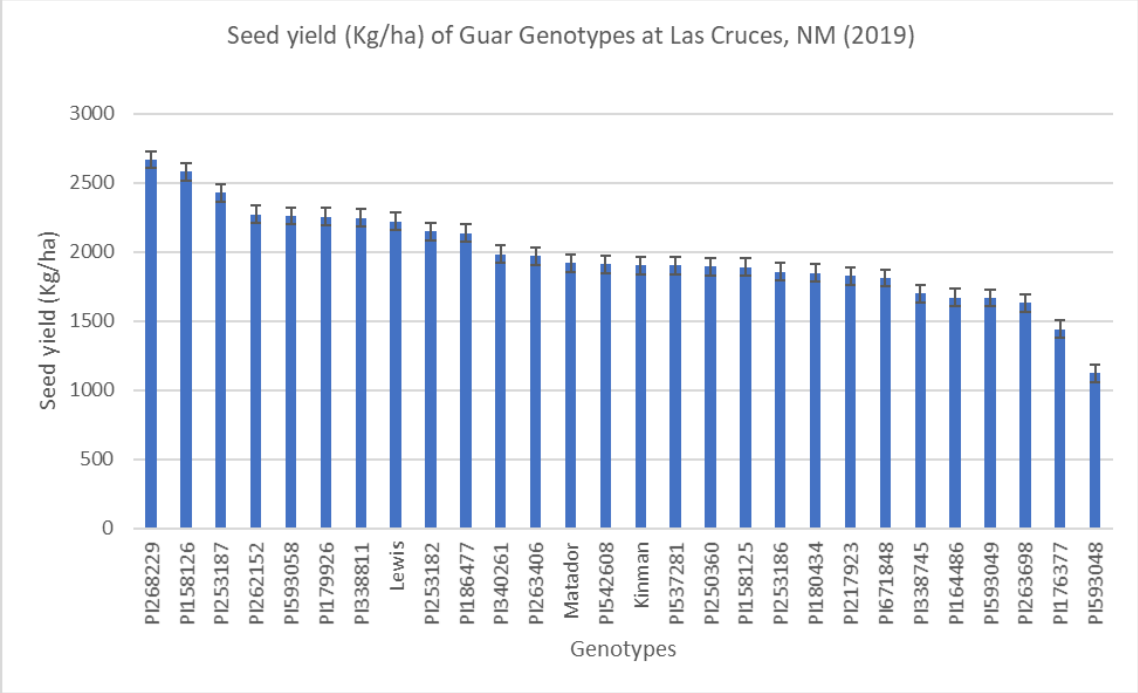

Figure 8. *Seed yield of guar genotypes at Fabian Garcia Plant Science Center, Las Cruces, New Mexico (2019).*

Genotypes PI671848 produced the highest number of clusters/plant followed by PI268229 and PI158126 (38, 31, and 30 clusters/plant, respectively). Genotypes PI 340261, PI 338745 and PI 186477 had the lowest number of clusters/plant and produced less than 50% number of clusters than the highest producing genotypes (Figure 9).

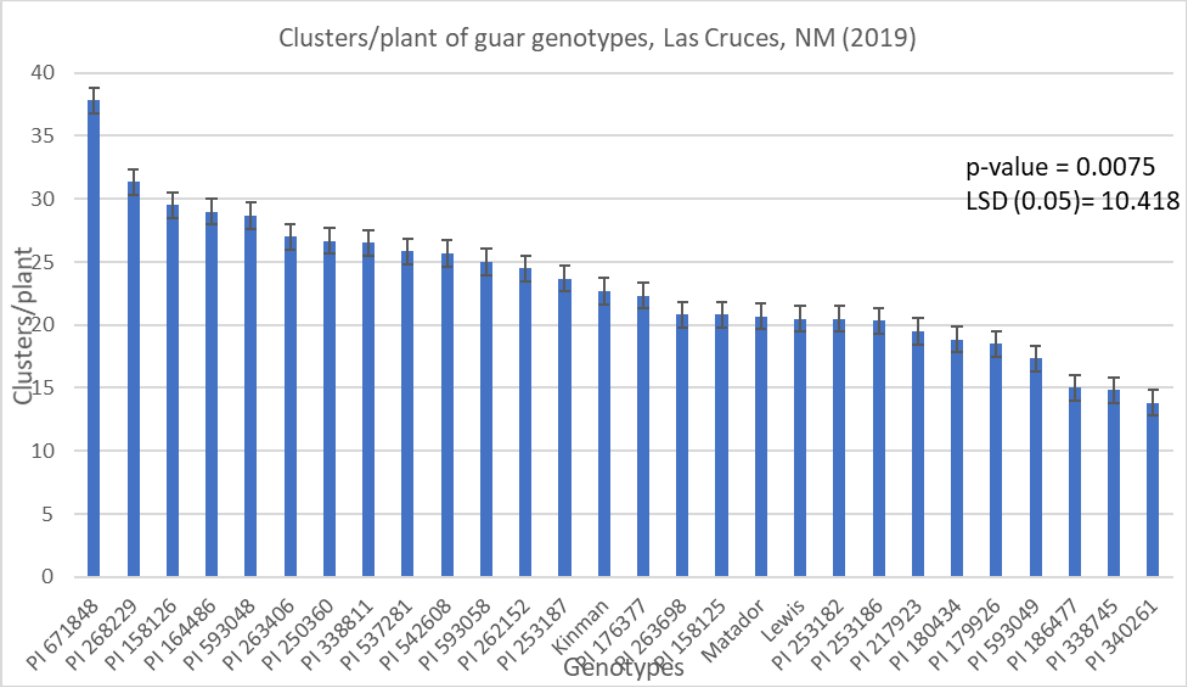

Figure 9. *Number of clusters per plant of guar genotypes at Fabian Garcia Plant Science Center, Las Cruces, New Mexico (2019).*

Genotype PI 176377 had the highest 100-seed weight (4.1 g) followed by genotypes PI 158126 and PI 263406 (3.7 and 3.5 respectively) while the genotypes PI 179926, PI 263698 along with Kinman resulted in the lowest 100-seed weight that ranged from 2.5-2.6 g (Figure 10).

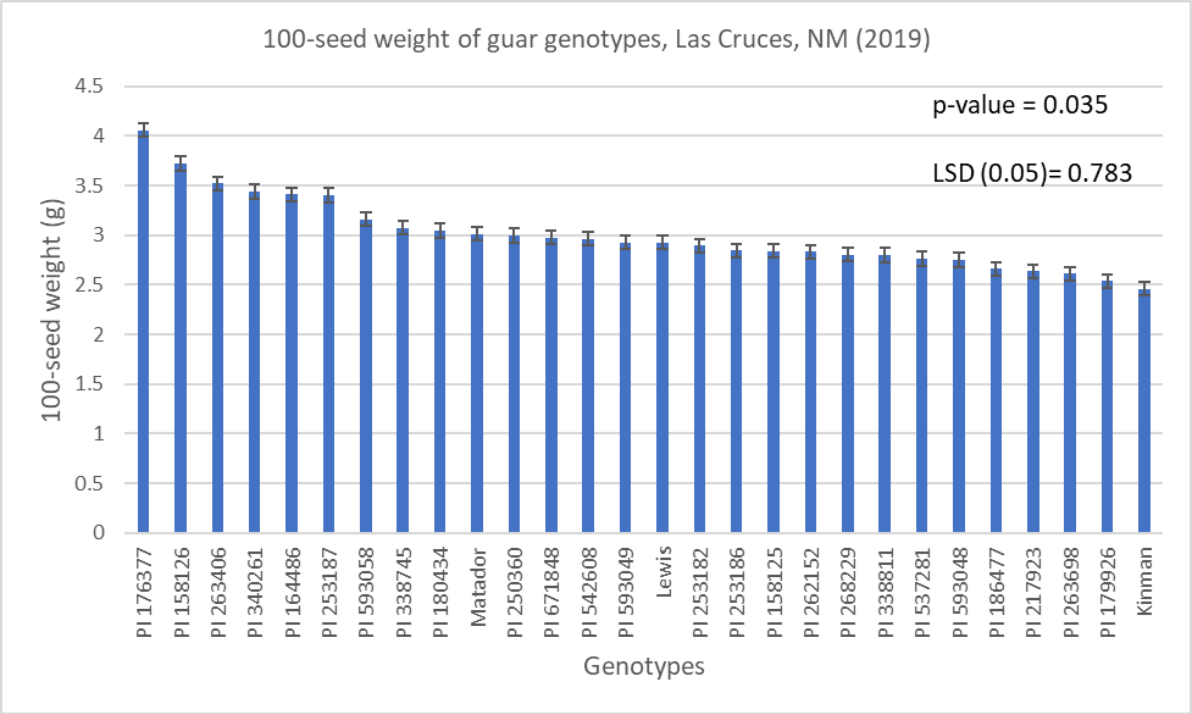

Figure 10. *100 seed weight of guar genotypes at Fabian Garcia Plant Science Center, Las Cruces, New Mexico (2019).*

PI263406, PI599058 and Lewis had the highest pod thickness among the genotypes (Figure 11).

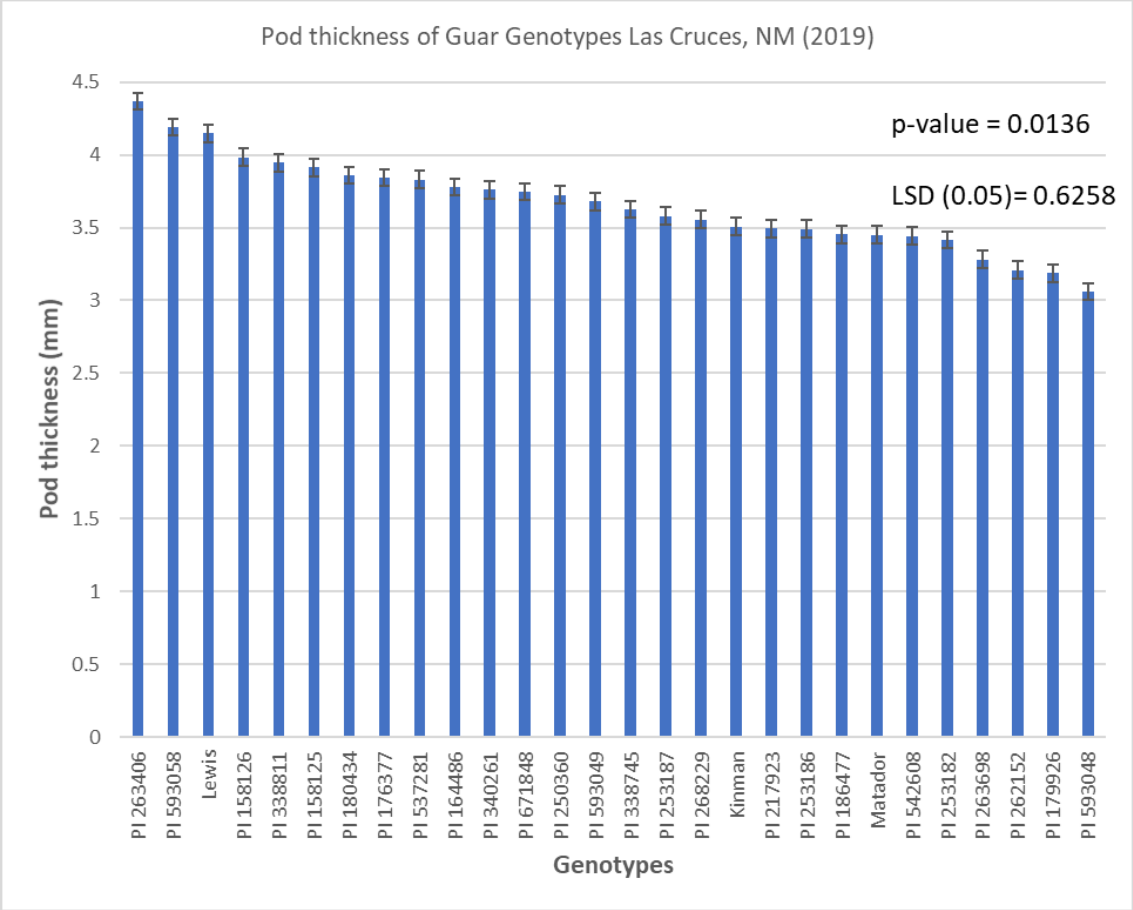

Figure 11. *Pod thickness (mm) of guar genotypes at Fabian Garcia Plant Science Center, Las Cruces, New Mexico (2019).*

Seed Evaluation following Root Inoculation and Root Inoculation per Guayule Germplasm:
No new data to report. Work on new screenings has stopped until new sources of the root rot fungus are obtained.

Guayule Salt Tolerance Trials:
Surviving plants from salt stress experiments were moved from pots in the greenhouse to the field. (Figure 12)

Photo 1. *Student worker (Alex Peck) grading guayule plants in the greenhouse, Tucson, Arizona.*

19-May-20

	Position	Salt survivors Part II (3 rows per line, 1 empty row between lines in field)																
	1	R1101	R1101	R1101	4265X	4265X	4265X	R1093	R1093	R1093	11634	11634	11634	11605	11605	11605	Parl922	Parl922	Parl922
^	2	R1101	R1101	R1101	4265X	4265X	4265X	R1093	R1093	R1093	11634	11634	11634	11605	11605	11605	Parl922	Parl922	Parl922
|	3	R1101	R1101	R1101	4265X	4265X	4265X	R1093	R1093	R1093	11634	11634	11634	11605	11605	11605	Parl922	Parl922	Parl922
|	4	R1101	R1101	R1101	4265X	4265X	4265X	R1093	R1093	R1093	11634	11634	11634	11605	11605	11605	Parl922	Parl922	Parl922
N	5	R1101	R1101	R1101	4265X	4265X	4265X	R1093	R1093	R1093	11634	11634	11634	11605	11605		Parl922	Parl922	Parl922
	6	R1101	R1101	R1101	4265X	4265X	4265X	R1093	R1093	R1093	11634	11634	11634	11605	11605		Parl922	Parl922	Parl922
	7	R1101	R1101	R1101	4265X	4265X	4265X	R1093	R1093	R1093	11634	11634	11634	11605			Parl922	Parl922	Parl922
	8	R1101	R1101	R1101	4265X	4265X		R1093				11634		11605			Parl922	Parl922	Parl922
	9		R1101	R1101										11605					Parl922
	10																		Parl922

Salt Survivors Part I (? = unreadable label, unknown soldier)								
11609	11609	CFS24	P912	?	11591	p912	cal7	?
11609	11609	CFS24	P912	?	11591	p912	cal7	?
P805	11609	CFS24	P912	11609	11591	p912	cal7	?
	11609	CFS24	P912	N565	11633	p912	cal7	
	11609	4265X	P912	N565	11633	p912	cal7	
	11609	R1109	P912			p912	cal7	
			P912					

Figure 12. *Field layout of guayule plants that survived stress experiments.*

Guar Yield Trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM:

Guar yield trial was planted in Tucson on June 23 (Table 6, Figure 13). Breeding trial was planted on June 24 (Table 7, Figure 14).

Table 6. *Guar varieties and plot numbers planted on June 23, 2020.*

G1	SIRSA 56	104	228	301	427
G2	NO 10521	118	226	307	413
G3	NO 10949	110	209	302	419
G4	PI 186477	106	223	319	403
G5	EC 248A	123	219	324	425
G6	COL NO K619	121	222	311	405
G7	B-49819	105	212	310	415
G8	B-49823	119	205	322	421
G9	B-49824	122	203	326	411
G10	IC-83 NO 3	102	206	315	417
G11	COL NO 36 PUNJAB	107	208	327	407
G13	WKP-88-43	108	227	309	408
G14	PI 542608	115	213	303	422
G16	SURTI	109	211	321	406
G18	PI 263406	126	220	308	404
G19	PI 263698	116	207	325	402
G20	PLG 86	113	225	318	418
G22	PLG 241	128	204	317	423
G23	PLG 482	103	215	316	426
G26	TX73-2731	114	201	312	401
G27	TX71-3292	117	221	313	428
G28	G-05	120	214	328	416
G29	TX 78-3726	124	216	306	420
G30	SANTA C RUZ	127	210	304	412
G31	Matador	111	217	323	414
G32	Lewis AZ	125	224	320	424
G35	Lewis TX	112	218	314	409
G36	Kinman	101	202	305	410

← NORTH

422 G14 PI 542608	423 G22 PLG 241	424 G32 Lewis AZ	425 G5 EC 248A	426 G23 PLG 482	427 G1 SIRSA 56	428 G27 TX71-3292
415 G7 B-49819	416 G28 G-05	417 G10 IC-83 NO 3	418 G20 PLG 86	419 G3 NO 10949	420 G29 TX 78-3726	421 G8 B-49823
408 G13 WKP-88-43	409 G35 Lewis TX	410 Kinman	411 G9 B-49824	412 G30 SANTA C RU	413 G2 NO 10521	414 G31 Matador
401 G26 TX73-2731	402 G19 PI 263698	403 G4 PI 186477	404 G18 PI 263406	405 G6 COL NO K61	406 G16 SURTI	407 G11 COL NO 36 P
322 G8 B-49823	323 G31 Matador	324 G5 EC 248A	325 G19 PI 263698	326 G9 B-49824	327 G11 COL NO 36 P	328 G28 G-05
315 G10 IC-83 NO 3	316 G23 PLG 482	317 G22 PLG 241	318 G20 PLG 86	319 G4 PI 186477	320 G32 Lewis AZ	321 G16 SURTI
308 G18 PI 263406	309 G13 WKP-88-43	310 G7 B-49819	311 G6 COL NO K61	312 G26 TX73-2731	313 G27 TX71-3292	314 G35 Lewis TX
301 G1 SIRSA 56	302 G3 NO 10949	303 G14 PI 542608	304 G30 SANTA C RU	305 Kinman	306 G29 TX 78-3726	307 G2 NO 10521
222 G6 COL NO K61	223 G4 PI 186477	224 G32 Lewis AZ	225 G20 PLG 86	226 G2 NO 10521	227 G13 WKP-88-43	228 G1 SIRSA 56
215 G23 PLG 482	216 G29 TX 78-3726	217 G31 Matador	218 G35 Lewis TX	219 G5 EC 248A	220 G18 PI 263406	221 G27 TX71-3292
208 G11 COL NO 36 P	209 G3 NO 10949	210 G30 SANTA C RU	211 G16 SURTI	212 G7 B-49819	213 G14 PI 542608	214 G28 G-05
201 G26 TX73-2731	202 Kinman	203 G9 B-49824	204 G22 PLG 241	205 G8 B-49823	206 G10 IC-83 NO 3	207 G19 PI 263698
122 G9 B-49824	123 G5 EC 248A	124 G29 TX 78-3726	125 G32 Lewis AZ	126 G18 PI 263406	127 G30 SANTA C RU	128 G22 PLG 241
115 G14 PI 542608	116 G19 PI 263698	117 G27 TX71-3292	118 G2 NO 10521	119 G8 B-49823	120 G28 G-05	121 G6 COL NO K61
108 G13 WKP-88-43	109 G16 SURTI	110 G3 NO 10949	111 G31 Matador	112 G35 Lewis TX	113 G20 PLG 86	114 G26 TX73-2731
101 Kinman	102 G10 IC-83 NO 3	103 G23 PLG 482	104 G1 SIRSA 56	105 G7 B-49819	106 G4 PI 186477	107 G11 COL NO 36 P
BORD	BORD	BORD	BORD	BORD	BORD	BORD
1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

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Figure 13. *Map of field for guar variety trial planted June 23, 2020.*

Photo 2. *Student workers (Juan Salas and Leo Moreno) with Valerie Teetor planting guar yield trial, Tucson, Arizona.*

Table 7. *Guar breeding selections (sel#) and plot numbers planted on June 24, 2020.*

sel #		rep 1	rep 2
1	G27A	109	203
2	G25A	120	216
3	G9A	118	208
4	G6A	101	204
5	Santa Cruz TX	107	214
6	G12	103	202
8	G16A	114	215
9	G24A	119	207
10	G28A	115	220
11	G33 MS row 18	117	206
12	G34 MS row 26	111	210
13	CMS -S1 x Matador	102	213
15	CMS x Lewis row 21	106	205
16	CMS x Lewis row 24	110	217
17	G33 row 21	104	212
18	G12	113	201
20	Matdor	116	211
	plot 413 G13	112	209
	Vol. HT. 6' single stalk	108	219
	2019 composite	105	218

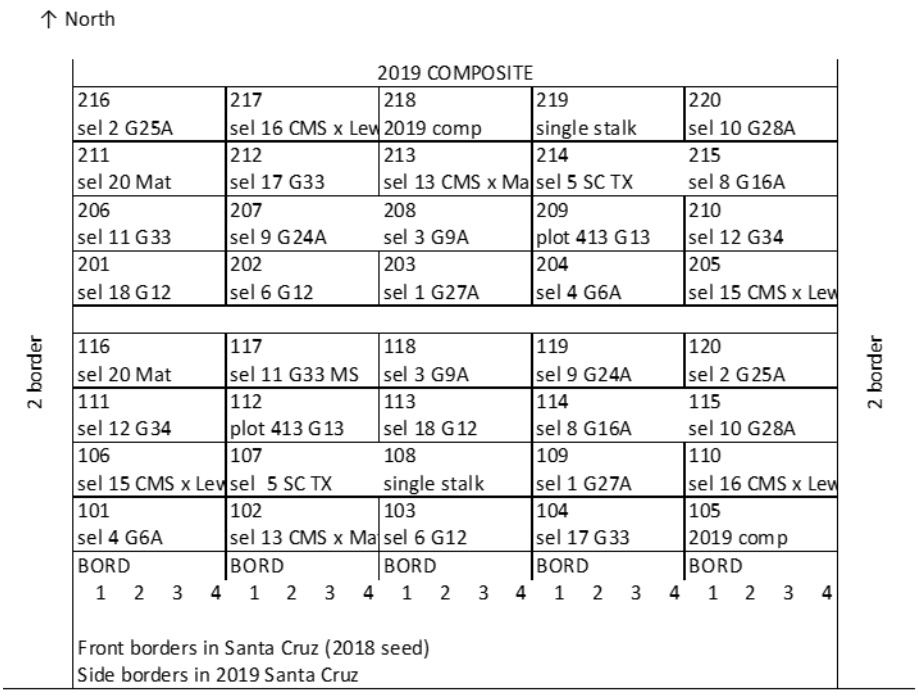

Figure 14. *Map of field for guar breeding trial planted on June 24, 2020.*

Photo 3. *Student worker (Juan Salas) with Dr. Dennis Ray planting the guar breeding trial, Tucson, Arizona.*

Guar Genetic Combination Trials:
Research for this task is complete.

Objective 4. Deploy agronomic production practices; identify agronomic information for salinity, herbicide, and nutrients to support production; provide irrigation apps using algorithms to growers.

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Conduct guar critical stage-based deficit irrigation trial	Report on growth stage-based irrigation management Present data at regional and national conferences	15 May 20 15 May 20
2 Angadi	Guar germplasm temperature requirement	Identify optimum soil temperature for planting USDA guar germplasm	31 Jul 20
3 Dierig	Density trials in Tucson and Eloy, AZ	Establish trial with different densities in Tucson, AZ Summarize plant growth, yield performance, and traits for density trial with 2 varieties and 5 densities in Eloy, AZ Final harvest and analysis completed for 5 plant densities and 2 varieties in Eloy	31 Dec 20 30 Apr 22 30 Apr 20
4 Dierig	Bi-monthly harvest from irrigation trials	Growth data over seasons from two locations Harvest plots for shrub dry biomass rubber/resin content and yield	31 May 20 30 Apr 20
5 Dierig	Irrigation Timing Study	Plant replicated trial and begin treatments	31 Aug 20
6 Grover	Evaluate guar response to moisture stress	Track and collect research data on moisture stress experiment Generate report/publication from results obtained Present research results at regional/national conferences	31 Aug 20 31 Aug 20 31 Aug 20
7 Grover	Evaluate guar response to planting density	Track and collect research data on guar density experiment Generate report/publication from results obtained	31 Aug 20 31 Aug 20
8 McClos	Conduct guayule herbicide tolerance study, at Eloy and Maricopa, AZ (Fall)	Collect data to support 24c SLN herbicide registrations – (a) topical, postemergence broadleaf herbicide; (b) post-directed herbicide; (c) herbicide application sequence for	28 Feb 20

		chemical weed control from seeding to 6mo old plants Generate research report/publication and Extension bulletin from results obtained	 30 Jun 20
9 McClos	Conduct guayule herbicide tolerance studies, at Eloy and Maricopa, AZ (Spring)	Collect data to support 24c SLN preemergence herbicide registrations – (a) topical, postemergence broadleaf herbicide; (b) post-directed herbicide; (c) herbicide application sequence for chemical weed control from seeding to 6mo old plants Generate research report/publication and Extension bulletin from results obtained	30 Jun 20 30 Jun 20
10 Ogden	Development and testing of AquaCrop model	Growth model compared to field data	30 Apr 20
11 Ogden	Development of BioCrop model	Preliminary output and evaluation of most important parameters	31 Aug 20
12 Ray	Guayule density trial	Yields for 2 lines, 5 densities, 2 locations, and 2 seasons compared	30 Nov 21
13 Ray	Range of N and P application	Compare N and P utilization and effects of nutrients on biomass, rubber and resin production	30 Nov 20
14 Waller	Install TDR, infrared camera and flowmeter system	Provide data on guayule irrigation experiments Provide data set that can be used to refine the use of sensors for WINDS crop irrigation mgmt.	15 Jul 20 15 Jul 20
15 Waller	Integrate python MySQL WINDS model with existing tools	Integrate new python model with WINDS (winds.arizona.edu), and in-situ sensors Database available to economic modelers	15 Jul 20 15 Jul 20
16 Waller	Irrigation experiments: Guayule and Guar	Collect data; image collection, neutron probe readings, in-situ sensors, crop coefficient development and destructive plant samples for chemical analysis Document effects of irrigation treatment on plant growth, soil moisture, plant stress, plant	15 Jul 20 15 Jul 20

		chemical response, plant vegetative indices, and crop coefficient Generate a publication on guayule irrigation experiments	 15 Jul 20
17 Waller	Deficit irrigation study (water stress); Eloy, AZ	Quantify effects of irrigation scheduling strategies on rubber/biomass yield and plant stress	15 Jul 20

Guar Critical Stage-Based Deficit Irrigation Trial:
Guar deficit irrigation trial was planted on June 2nd 2020. Crop establishment is very good. We have initiated irrigation treatments and seasonal observations. Jagdeep Singh, MS student submitted his thesis on the project and moved on to another university to pursue his Ph.D. Due to unusual second season, we are delaying publications from this project. He has written two chapters in the form of manuscripts from the project, which will be revised after 2020 data becomes available and submitted to journals.

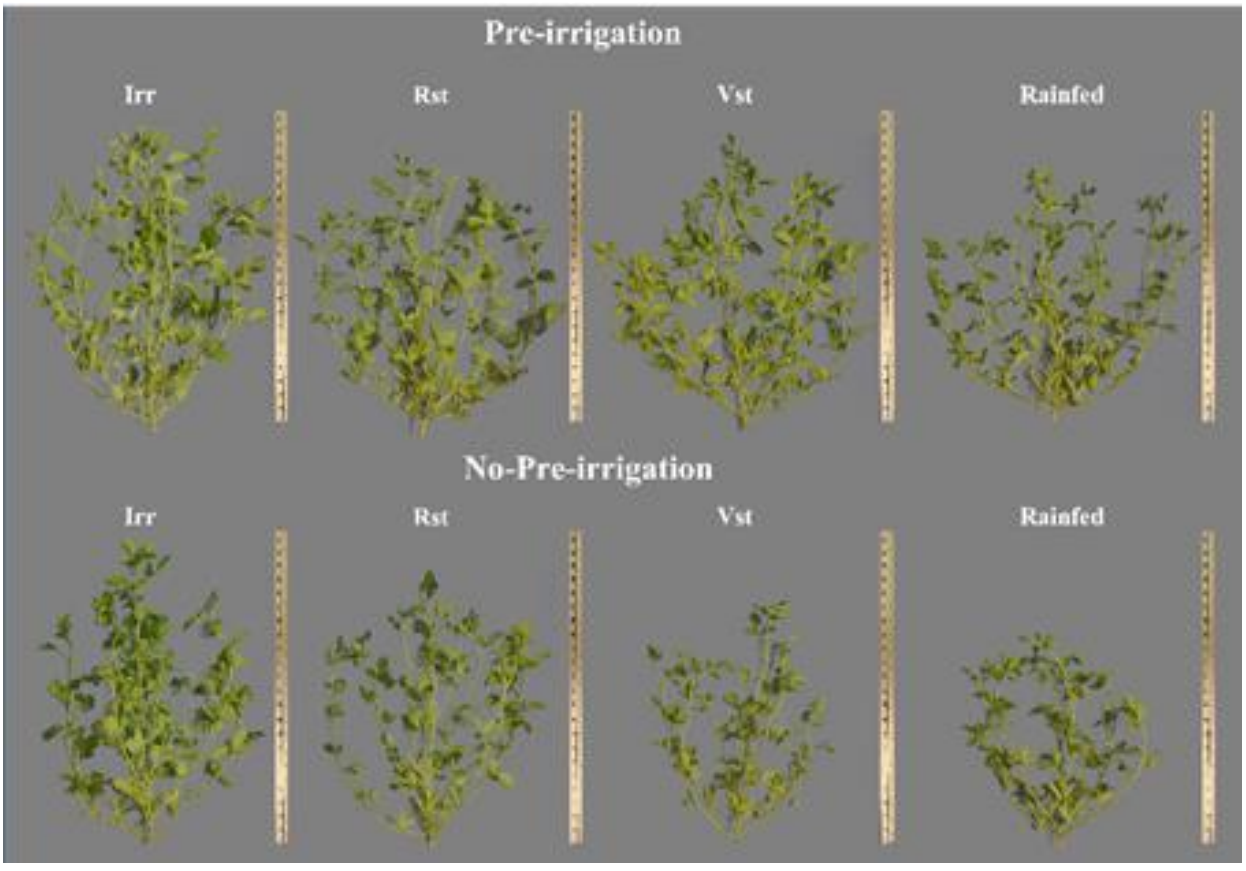

Figure 15. *Visual representation of guar growth between pre-irrigation (127-119 mm) and no-pre-irrigation (0 mm) treatments in Clovis, New Mexico.*

Incubator Study to Understand Temperature and Germination Relationships:
The incubator study that focused on assessing genetic variation among guar cultivars for temperature and crop establishment relationships has been completed. The manuscript written by Jagdeep Singh has been reviewed by all co-authors. Final version is being prepared for submission to Industrial Crops and Products journal. We anticipate to submit in 2-3 days. Continuation of this work to assess guar germplasm from germplasm bank has been delayed due to COVID-19. We are also trying to develop root growth assessment protocol using a paper scanner to assess diversity in root development in diverse guar cultivars under different temperatures. Initial runs were promising. We have to wait for the next graduate student to continue the work.

Density Trials in Tucson and Eloy, AZ:
The densities are 30, 18, 12, 6, 3-inch in-row spacing for density 1, 2, 3, 4, 5. Plots were harvested for year 1.5 at Eloy and year 1 at Tucson in October. Data for Tucson are found in PI D.T. Ray 2019 Q4 report.

Rubber and resin content are currently being analyzed and full results including rubber yield will be included in Q3 reporting. The same experiment was planted at Tucson in September 2018. The second harvest will be conducted there in Fall, 2020, when crop is 2-years old.

Bi-Monthly Harvest from Irrigation Trials:
The fields at Eloy and Maricopa were harvested in January and March 2020. These were the final bimonthly harvests, but we will sample regrowth after 6 months. The results over the 2-year study are shown below.

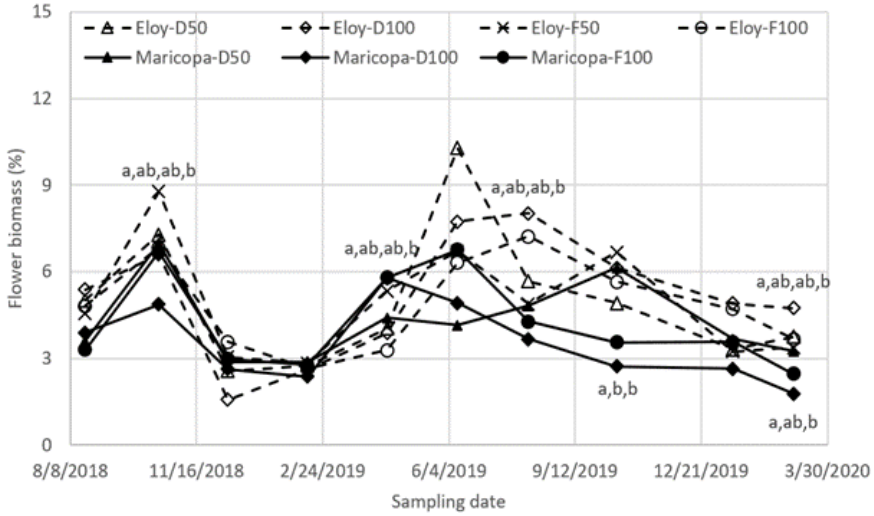

Figure 16. *Flower biomass partitioning of guayule over the growing period under different irrigation treatments at Eloy (clay soil) and Maricopa (sandy-loam soil), Arizona.*

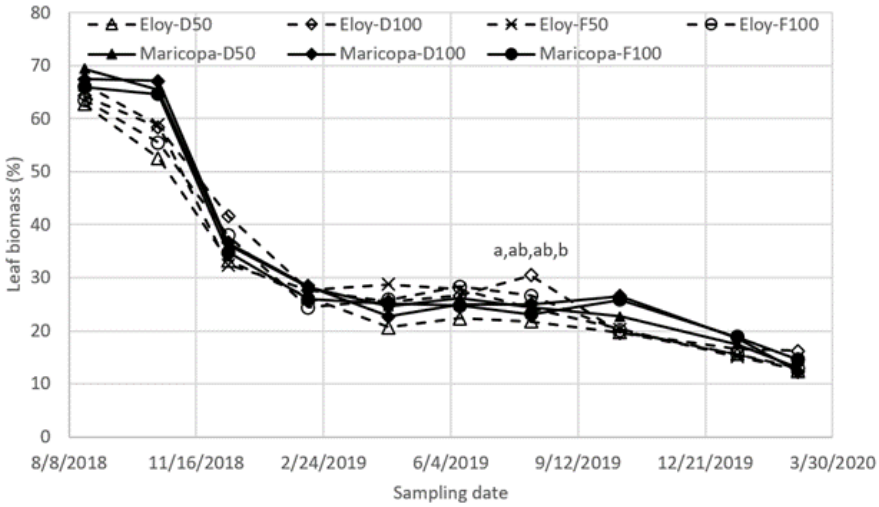

Figure 17. *Leaf biomass partitioning of guayule over the growing period under different irrigation treatments at Eloy (clay soil) and Maricopa (sandy-loam soil), Arizona.*

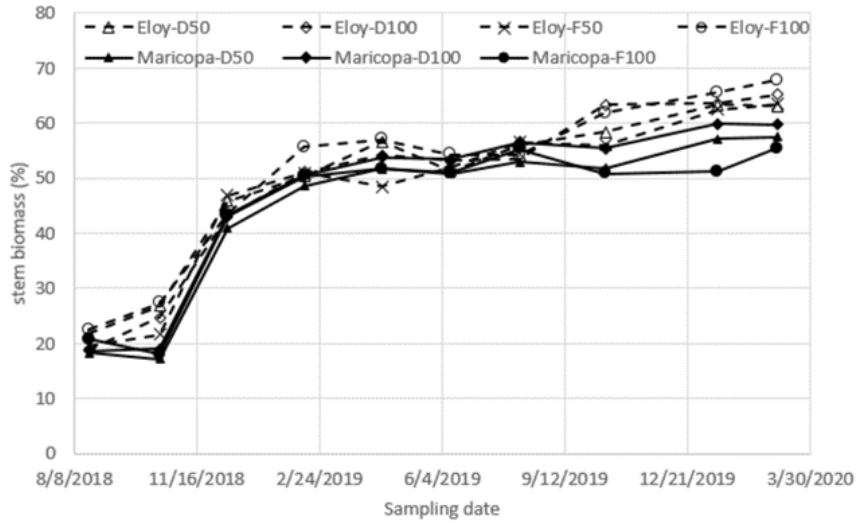

Figure 18. *Stem biomass partitioning of guayule over the growing period under different irrigation treatments at Eloy (clay soil) and Maricopa (sandy-loam soil), Arizona.*

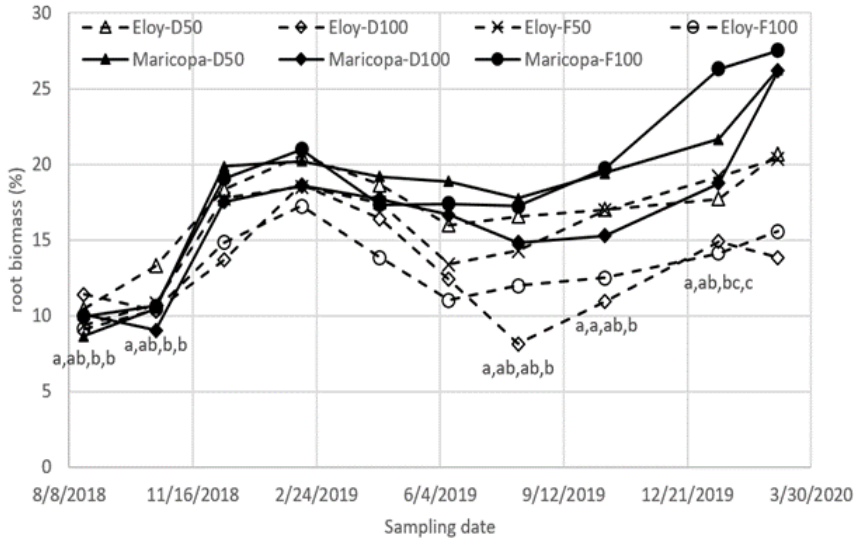

Figure 19. *Root biomass partitioning of guayule over the growing period under different irrigation treatments at Eloy (clay soil) and Maricopa (sandy-loam soil), Arizona.*

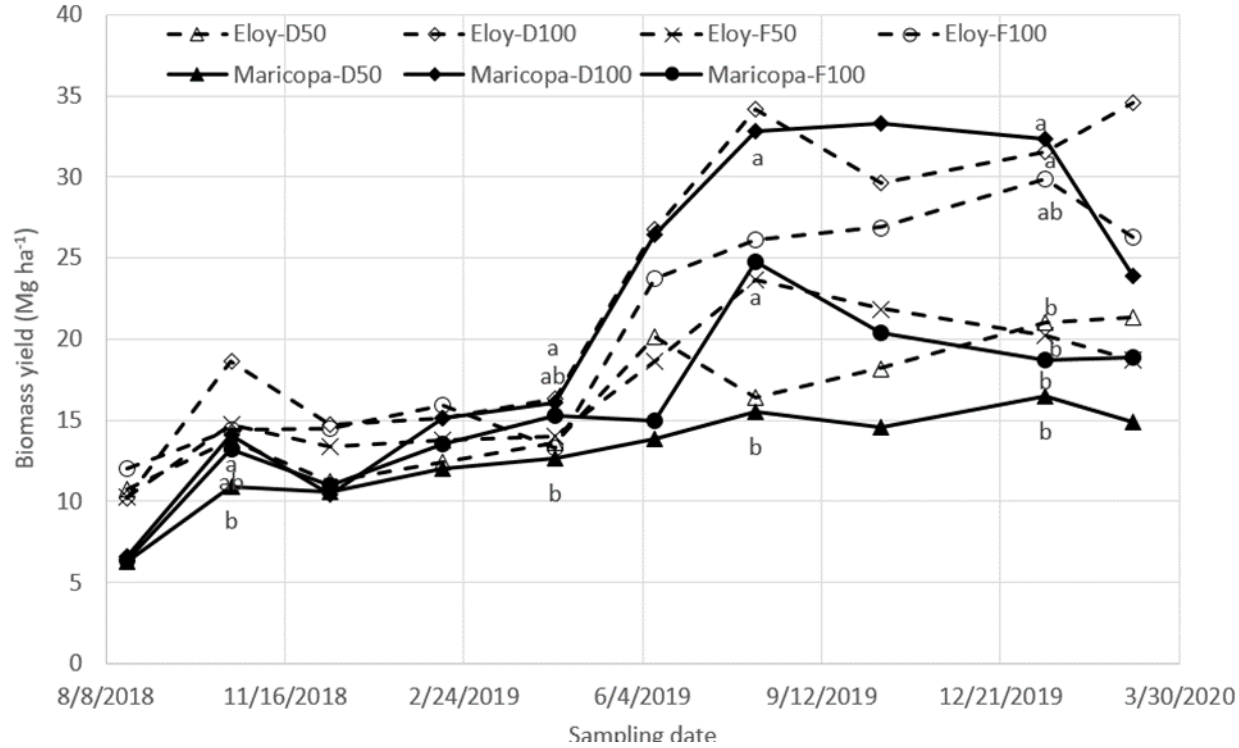

Figure 20. *Guayule biomass yield over growing period under different irrigation treatments at Eloy and Maricopa, Arizona.*

Overall, higher biomass at Eloy clay soil compared to MAC sandy-loam soil. Highest in Drip 100 and lowest in Flood 50 at Eloy; the same for MAC, however, since there was no Flood 50 treatment at MAC the Drip 50 treatment produced the least amount of biomass. Differences

between treatments were not seen until the second season at both locations, indicating fewer irrigations could be applied during the first year.

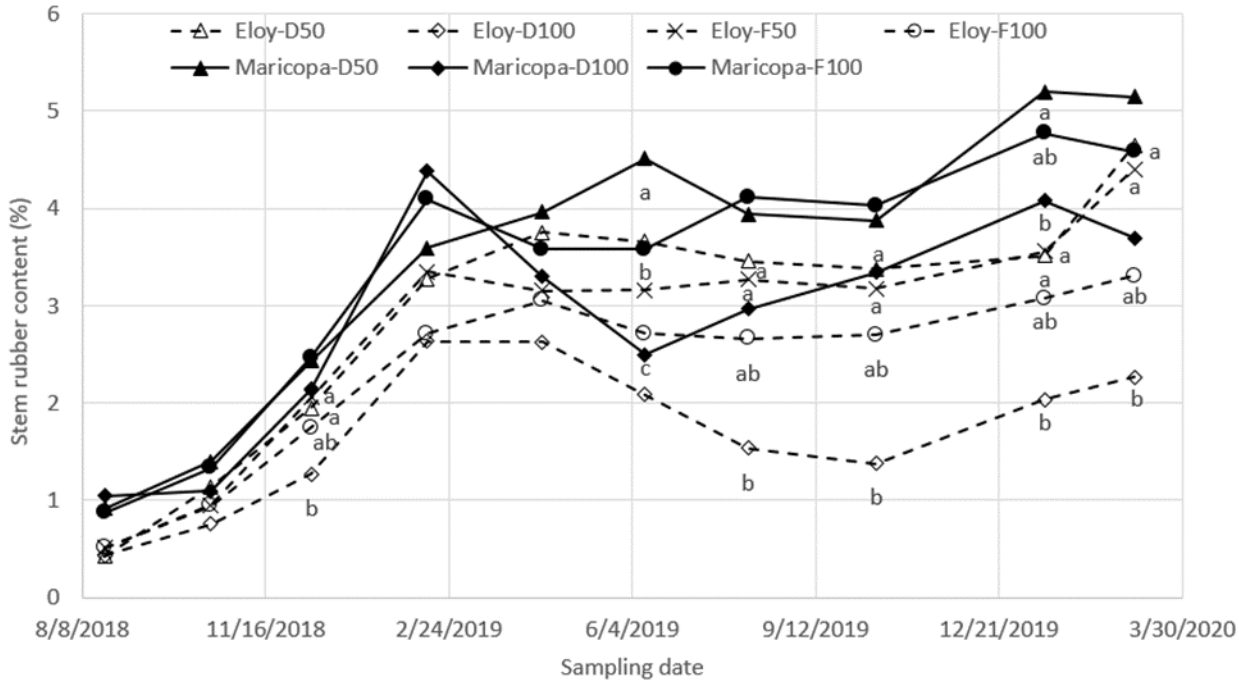

Figure 21. *Rubber content in guayule stem over growing period under different irrigation treatments at Eloy and Maricopa, Arizona.*

Rubber %: Drip 50 and Flood 100 were highest in rubber % at both 1 and 2 years at MAC location and overall. The Drip 100 was lowest in rubber % at both locations. The Drip and Flood 50 were highest at both locations and not statistically different. The trends did not keep the same rank of treatments throughout the 2 years for rubber. Resin was much more consistent (Figure 22).

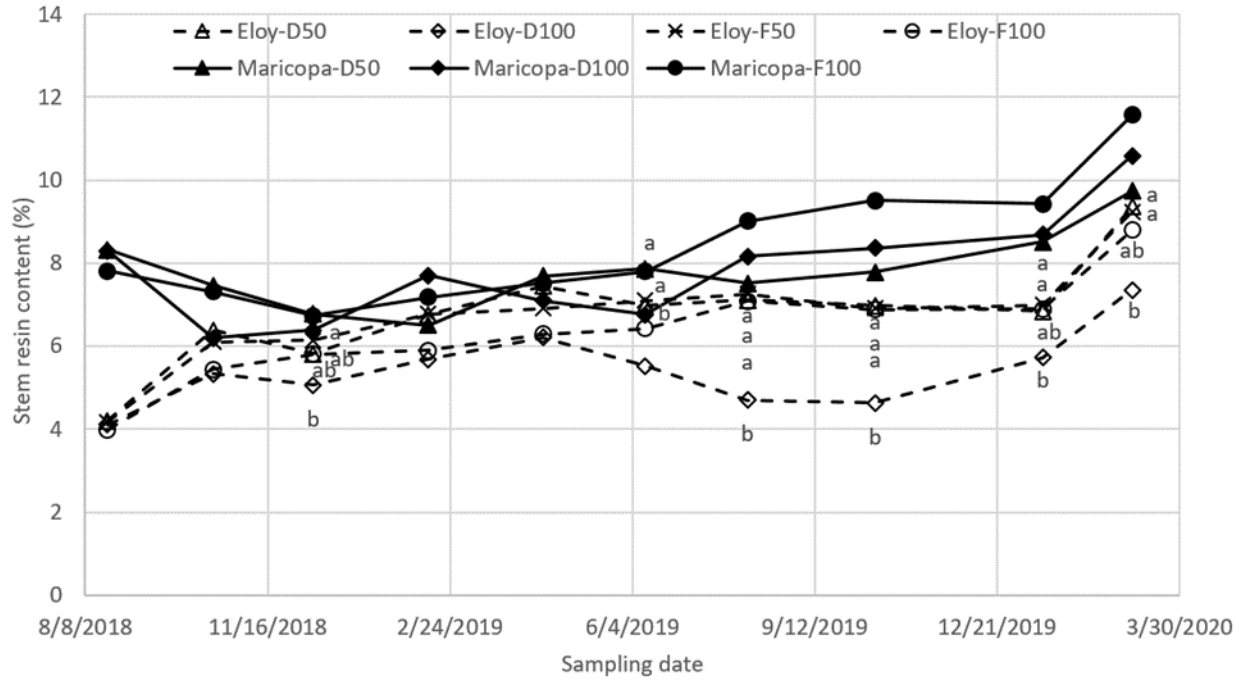

Figure 22. *Resin content in guayule stem over growing period under different irrigation treatments at Eloy and Maricopa, Arizona*

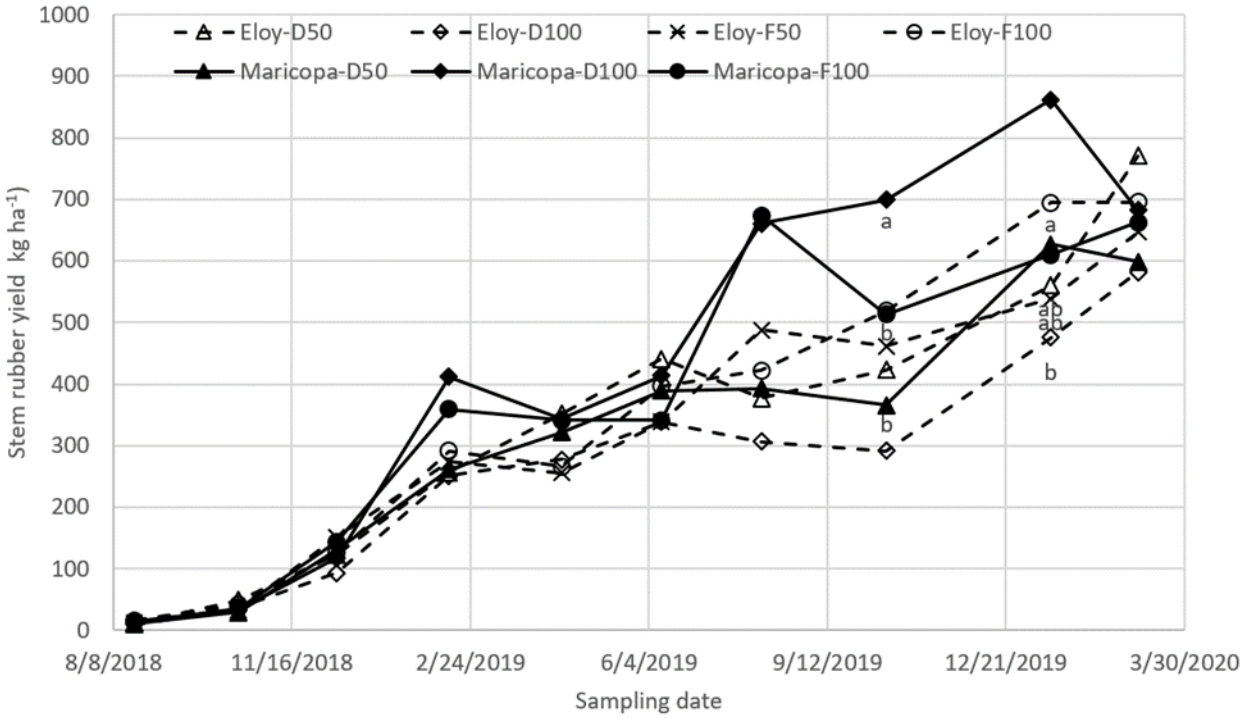

Figure 23. *Rubber yield of guayule stem over growing period under different irrigation treatments at Eloy and Maricopa, Arizona.*

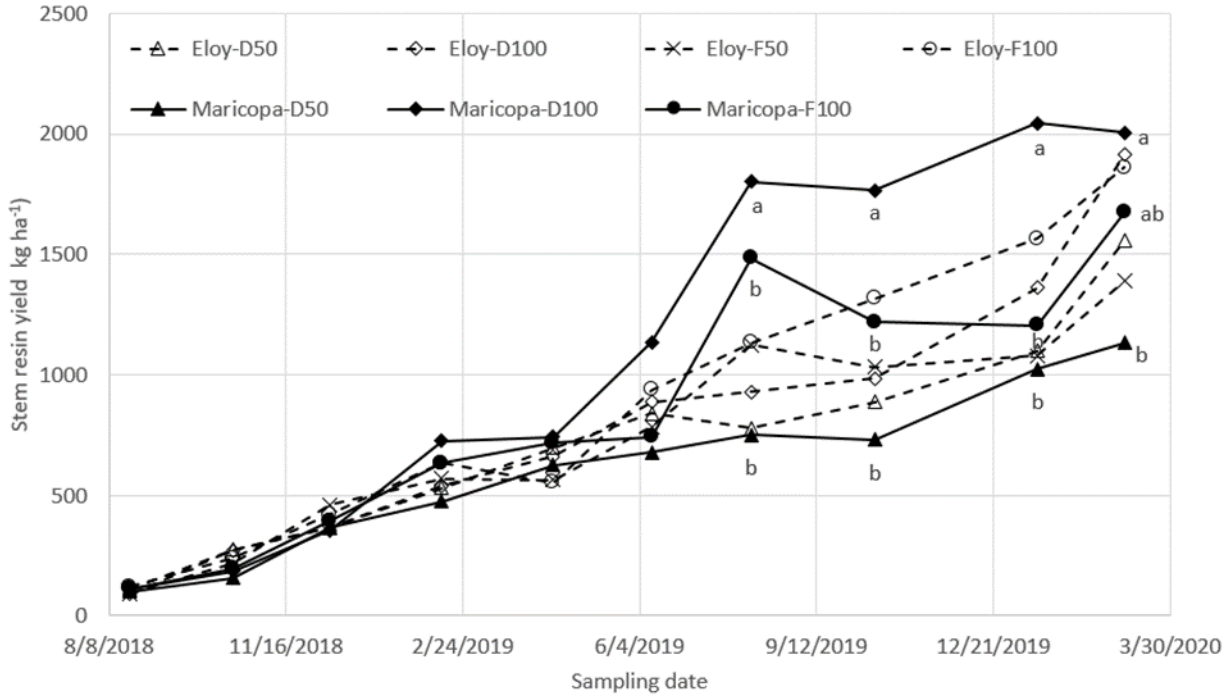

Figure 24. *Resin yield of guayule stem over growing period under different irrigation treatments at Eloy and Maricopa, Arizona.*

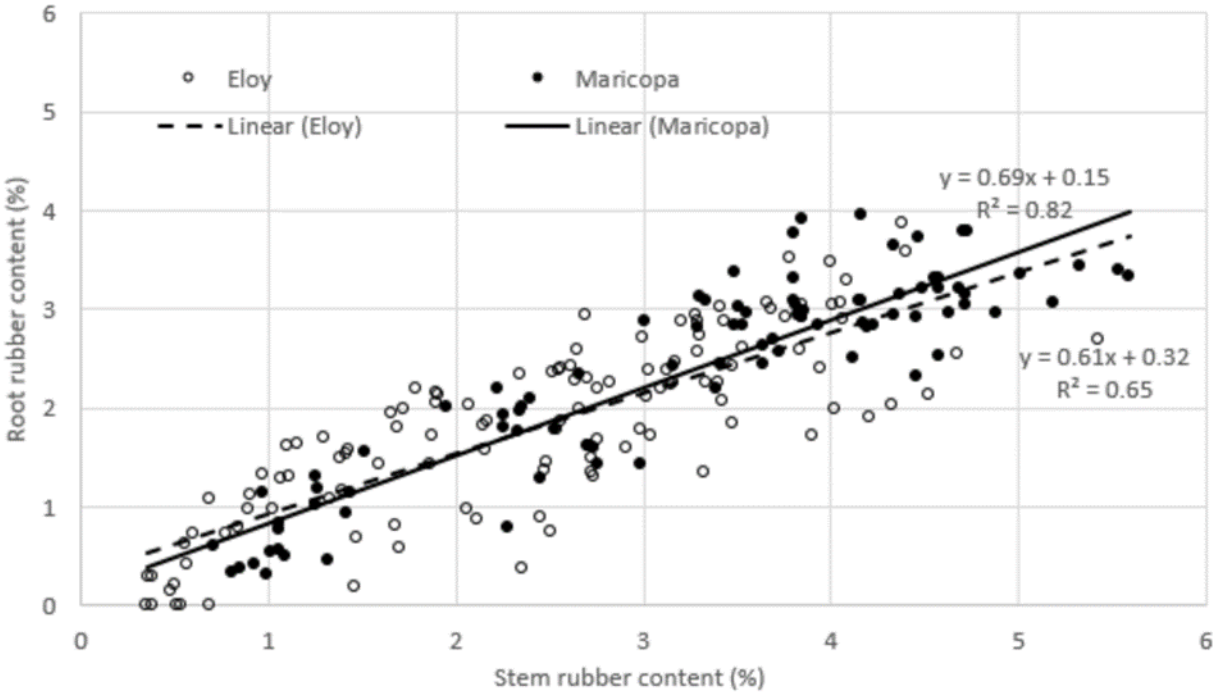

Figure 25. *Relationship between rubber content in stem and root in guayule under different irrigation treatments at Eloy and Maricopa, Arizona.*

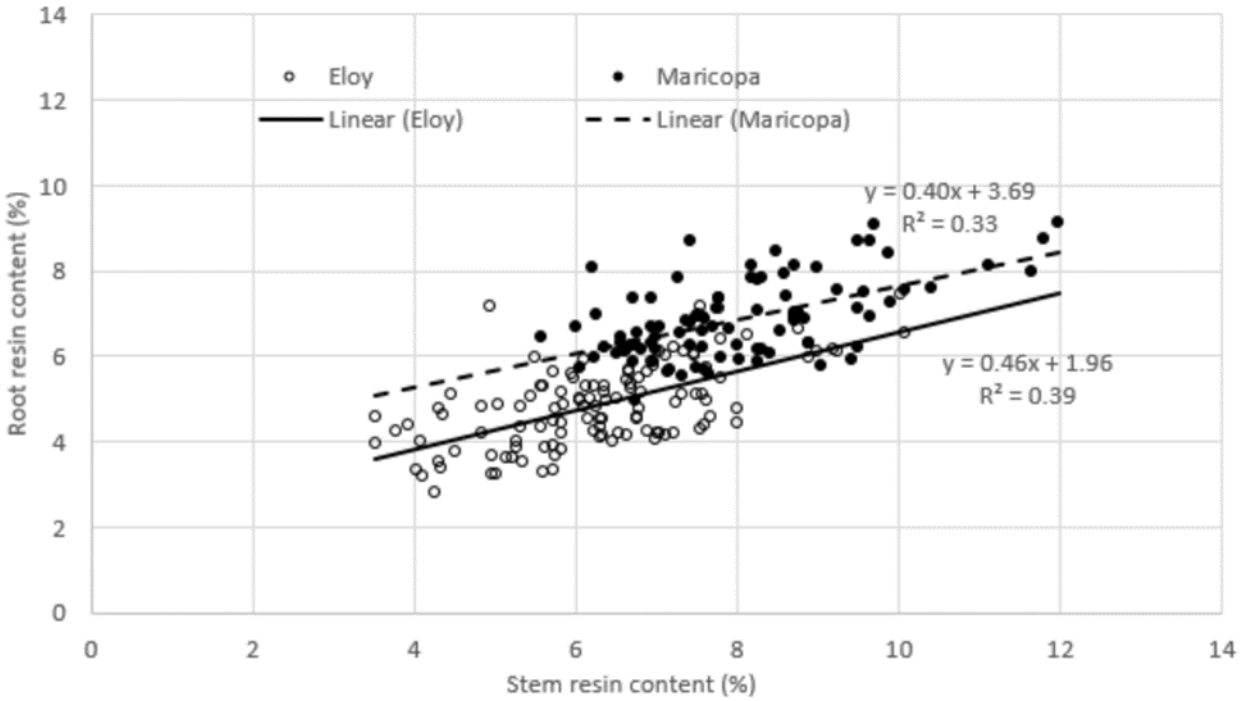

Figure 26. *Relationship between resin content in stem and root in guayule under different irrigation treatments at Eloy and Maricopa, Arizona.*

Irrigation Timing Study:
The field was prepared and planted on April 20. The treatments and varieties are listed below. Two germplasm lines (AZ-2 and Sel-1) and 3 replications planted at Eloy with furrow irrigation. There are 6 row plots 250 ft long plus two-row buffers between plots.

1. Full Irrigation: Irrigate as determined by the model developed as part of this project.
2. Stress for Harvest: Irrigate as treatment 1 for 1.5 years, then no irrigation.
3. Half Irrigation: Irrigate every other irrigation as determined by the model.
4. Minimum Irrigation: Irrigate three times per year, approximately every growth stage (May/June, September, and February).
5. Minimum Year2: Year 1 irrigate as determined by the model, and Year 2 irrigate three times (February, May/June, September).
6. One Irrigation: One irrigation after establishment in the first year, one irrigation in year 2.

Plants were established with solid state sprinklers for two weeks and then furrow irrigated. The last irrigation of all plots was the end of June, and the first irrigation of treatments will begin July 15, 2020. Growth measurements are in progress.

Guar Response to Moisture Stress:
Guar genotypes were evaluated for their growth and performance under five irrigation regimes including normal irrigation through the season; no irrigation at 50% pod formation; no irrigation

at 50% and 75% pod formation; early termination of irrigation at flowering; early termination of irrigation at flowering plus Biogenic Silica amendment.

The study was completed with 3-year data collected, compiled and analyzed. A Master's project was completed and thesis published. An abstract was submitted and presentation delivered at Western Crop Science Society of America conference. A manuscript draft is under preparation from these titled as: "Growth and Performance of Guar *Cyamopsis tetragonoloba* (L.) Taub under various irrigation regimes and biogenic silica addition in southwest New Mexico".

Stated Research Objective: Evaluate response of guar to irrigation regimes with and without biogenic silica amendment in southwest New Mexico.

Guar genotypes were evaluated for their growth and performance under five irrigation regimes including normal irrigation through the season; no irrigation at 50% pod formation; no irrigation at 50% and 75% pod formation; early termination of irrigation at flowering; early termination of irrigation at flowering plus Biogenic Silica amendment.

On average, the I1-normal irrigation produced the highest guar seed yield (2,715 kg ha-1) followed by I5-terminate irrigation at flowering + biogenic silica (2,469 kg ha-1) from 2016-2018 in Las Cruces (Table 8). As compared to the I1-normal irrigation, the I2-no irrigation at 75% pod formation and I3-no irrigation at 50% and 75% pod formation resulted in 20.8 % and 23.4% decline in guar seed yield, respectively. The I4-terminate irrigation at flowering had the lowest seed yield and had 26.4% decline in seed yield than I1-normal irrigation. The I5-terminate irrigation at flowering + biogenic silica had17.3% higher seed yield than I4-terminate irrigation at flowering indicating a positive impact of biogenic silica on guar growth under water stress conditions. Addition of biogenic silica in I5-terminate irrigation at flowering + biogenic silica increased seed yield through increasing yield attributing characteristics (clusters per plant, pods per plant and seeds per plant) and SPAD chlorophyll values as compared to I4-terminate irrigation at flowering that had not received any biogenic silica application.

Table 8. *1000 seed weight, harvest index and seed yield of guar under various irrigation regimes, at Las Cruces, New Mexico from 2016 to 2018.*

	1000 seed weight (g)			Harvest index			Seed yield (kg ha^{-1})		
	2016	2017	2018	2016	2017	2018	2016	2017	2018
Irrigation regime (I)									
$I_{1\text{-normal irrigation}}$	36.3	34.6ab	36.3	0.43a	0.29bc	0.25	2696a	2908	2542a
$I_{2\text{-no irrigation at 75\% pod formation}}$	36.4	32.3c	36.4	0.44a	0.28c	0.22	2314b	2622	1512b
$I_{3\text{-no irrigation at 50\% \& 75\% pod formation}}$	35.7	33.3c	35.7	0.44a	0.31ab	0.21	2253b	2543	1447b
$I_{4\text{-terminate irrigation at flowering}}$	35.9	33.5bc	35.9	0.44a	0.32a	0.22	2163b	2436	1399b
$I_{5\text{-terminate irrigation at flowering + biogenic silica}}$	35.2	35.1a	35.2	0.40b	0.32a	0.25	2913a	2717	1778b
Genotype (G)									
Kinman	35.1bc	32.7b	36.1a	0.43	0.33a	0.27a	2543a	2763	1845
Lewis	36.1b	33.5b	35.6a	0.43	0.29b	0.23b	2476a	2453	1668
Matador	34.8c	33.1b	33.7b	0.43	0.30ab	0.23b	2560a	2736	1876
NMSU-15-G1	37.5a	35.8a	36.7a	0.43	0.29b	0.19c	2291b	2629	1554
Interaction (I X G)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means within a column and particular effect not including letters do not differ at α <0.05 (Fisher's F-protected LSD).

Guar Response to Planting Densities:

Guar genotypes were evaluated for their seed yield and yield attributes under four seeding densities including 2, 4, 8 and 12 seeds/foot when planted on 40 inch spaced raised beds. Data was compiled and analyzed. Results are being summarized. When evaluated at single plant level, the lowest seeding density of 2 seeds/foot resulted in the highest plant biomass, number of pods as well as seed yield per plant basis followed by the 4 seeds/foot seeding density in 2018 and 2019 (Figures 27-29). The higher seeding density resulted in the lowest plant biomass, number of pods/plant and seed yield per plant that were significantly lower than the lowest seeding density of 2 seeds/foot in 2018 and 2019.

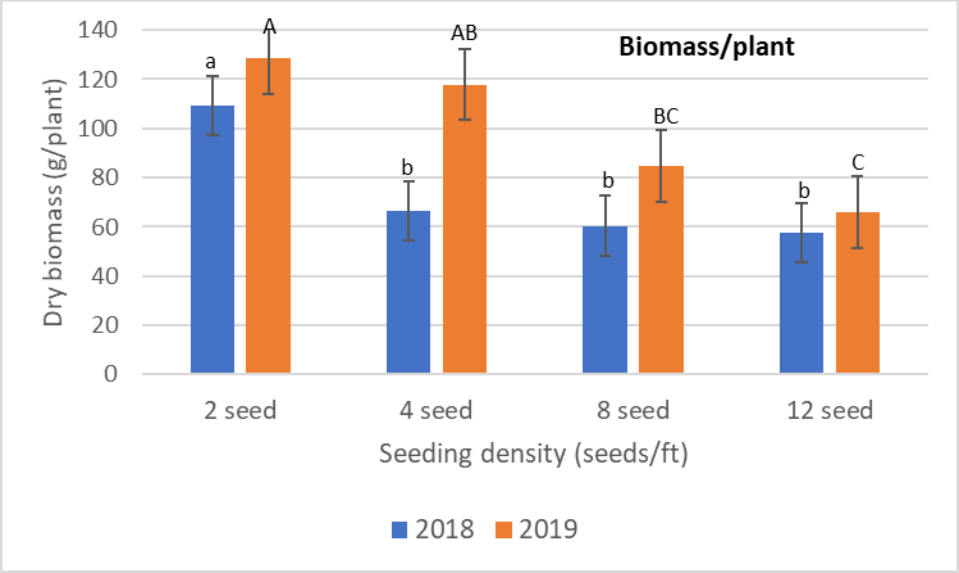

Figure 27. *Single plant biomass of guar genotypes under four seeding densities.*

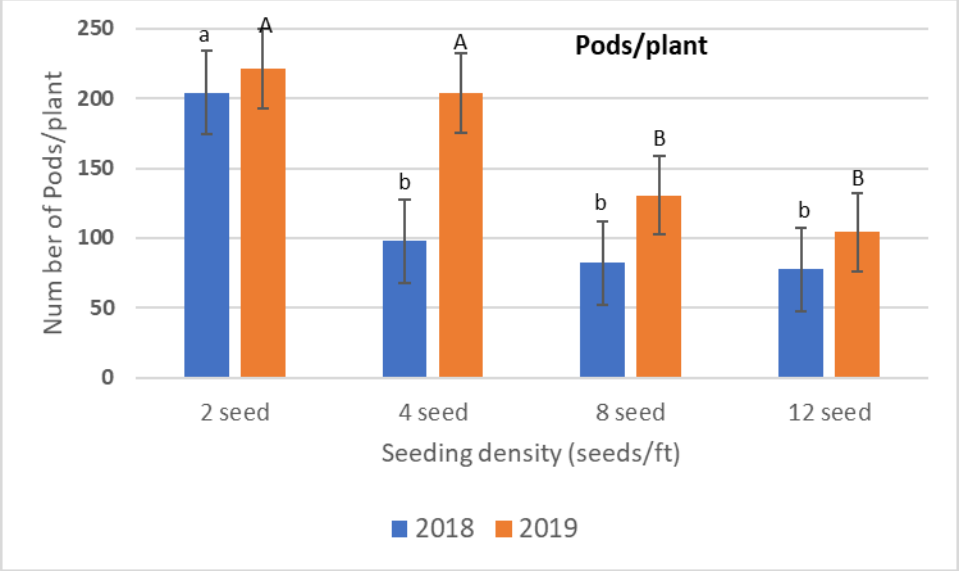

Figure 28. *Number of pods per plant of guar genotypes under four seeding densities.*

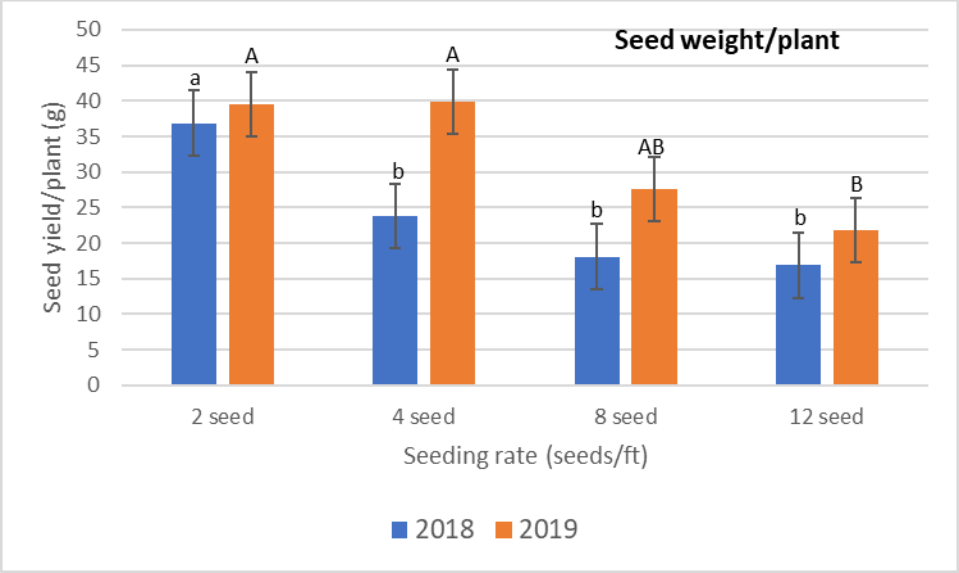

Figure 29. *Single plant seed yield of guar genotypes under four seeding densities.*

However, when comparing the overall seed yield, the guar genotypes produced highest seed yield when planted at higher seeding density of 12 seeds/foot followed by the 8 seeds/ft in both years (Figure 30). These results indicate that guar plants can be plastic in their growth and performance and produce higher yields at higher seeding density of 8-12 seeds/foot.

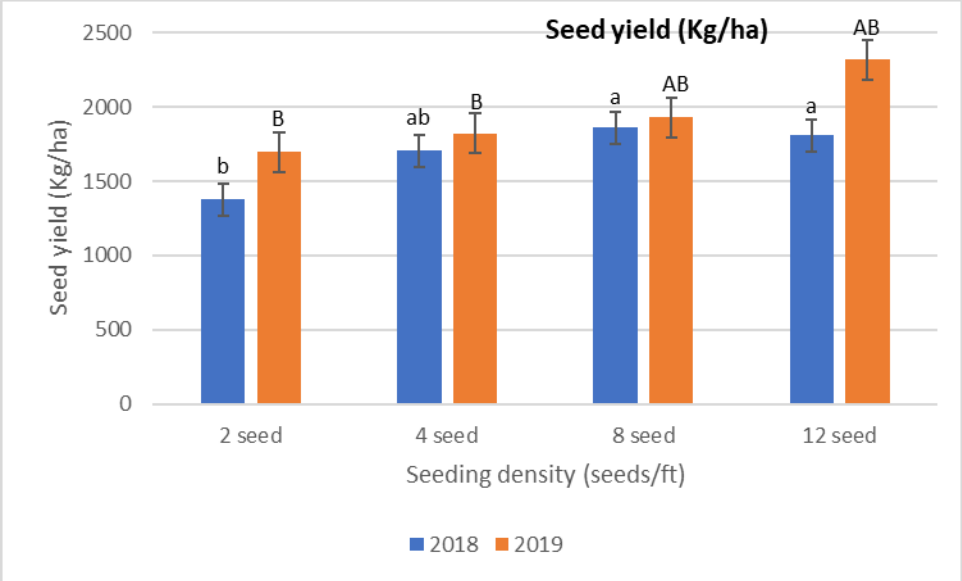

Figure 30. *Seed yield (kg/ha) of guar genotypes under four seeding densities.*

The study will continue in 2020 and was planted at Lyendecker Plant Science Center, Las Cruces, NM.

Guayule Herbicide Tolerance Study, Fall 2019:

None of the experiments started were successful due to a lack of seedling establishment as discussed in the 2019 Q4 report.

An initial screening study of herbicides post-directed at the base of plants and the soil between rows was completed in the guayule fields as discussed in the 2020 Q1 report.

Guayule Herbicide Tolerance Study, Spring 2020:

Following a 1-month delay due the SARS-COV2 virus, experiments were initiated at MAC and Bridgestone-Elly in April to a) study Aim herbicide injury on guayule when used with a methylated seed oil versus a non-ionic surfactant and to study the effects of early season sequential Aim applications on guayule growth. The preemergence herbicide studies in fall 2019 that failed were also repeated in spring 2020.

Several borders at MAC used in the spring 2020 preemergence herbicide studies will be retained to study the application of post-directed herbicide sprays of preemergence and postemergence herbicide chemistries on guayule that will be initiated in July/August 2020.

Photo 4. *Guayule's response to sequential Aim treatments, Maricopa Agriculture Center, Maricopa, Arizona.*

Herbicide Trials – Publication, Extension Bulletin and 24c SLN Applications

Quarter 2 was weird due to the SARS-COV2 virus an I did not find time to get much writing accomplished. Although I will be traveling for 8 weeks this summer, I expect to get much more done this fall including getting results published (e.g., a Research Report on the 2018 and 2019 Aim postemergence experiments).

Table 9. *Status of Fall 2019-Spring 2020 Herbicide Experiments*

Spray Date	Chemicals Applied	Location/ Field	Method of Application	ARM File Name / Data Tables?	Data Collected to Date
1-13-202019	Chateau, Goal Tender, Liberty, Caparol, Karmex, Matrix, Sandea, Rinskor, Butoxone 200	MAC / F1 / B48-49	The herbicides were mixed with the appropriate adjuvants and spray at the bottom 4 inches of canopy and the soil between the crop rows.	Guayule MAC F1B48-49_Winter 2019-2020 PostDirect	Data on plant death and, necrosis of basal leaves was collected. Starting variation in plant heights precluded evaluating stunting but in general no stunting was observed and no plants died.

Spray Date	Chemicals Applied	Location/ Field	Method of Incorporation	ARM File Name / Data Tables?	Data Collected to Date
4-20-2020	Spartan Prefar	MAC / F5E / B12	PPI-bedtop incorporvator		5/28/2020 – Guayule 3 m stand counts 6/11/2020 – Guayule 3 m stand counts 7/07/2020 – Nadir photographs
4-20-2020	Warrant Dual Magnum	MAC / F5E / B13	PPI-bedtop incorporvator		5/28/2020 – Guayule 3 m stand counts 6/11/2020 – Guayule 3 m stand counts 7/07/2020 – Nadir photographs
4-14-2020	Dual Magnum Warrant Spartan Prefar	MAC / F5E / B14	PPI-flat, field cultivator, lister, mulcher, bed-shaper		5/27/2020 – Guayule 3 m stand counts 6/11/2020 – Guayule 3 m stand counts 7/07/2020 – Nadir photographs
4-14-2020	Prowl H2O	MAC / F5E / B15	PPI-flat, field cultivator, lister, mulcher, bed-shaper		5/27/2020 – Guayule 3 m stand counts 6/11/2020 – Guayule 3 m stand counts 6/30/2020 – Nadir photographs
4-20-2020	Prowl H2O	MAC / F5E / B16	PPI-bedtop incorporvator		5/27/2020 – Guayule 3 m stand counts 6/15/2020 – Guayule 3 m stand counts 6/30/2020 – Nadir photographs
4-14-2020	Sonalan	MAC / F5E / B17	PPI-flat, field cultivator, lister, mulcher, bed-shaper		5/27/2020 – Guayule 3 m stand counts 6/15/2020 – Guayule 3 m stand counts 6/30/2020 – Nadir photographs
4-20-2020	Sonalan	MAC / F5E / 18	PPI-bedtop incorporvator		5/26/2020 – Guayule 3 m stand counts 6/15/2020 – Guayule 3 m stand counts 6/30/2020 – Nadir photographs
4-20-2020	Prowl H2O Dual Magnum Spartan Prefar Aim	MAC / F5E / B19	PPI-flat with field cultivator, sequential PPI-bedtop with incorporvator		6/4/2020 – Nadir photographs 6/25/2020 – Guayule 3 m stand counts and leaf counts 6/26/2020 – Bulk AIM spray 7/8/2020 – Guayule 3 m stand counts 7/10/2020 – Nadir photographs
5-29-2020	AIM	MAC / F5E / B20	Prowl PPI-flat with field cultivator, Aim sprayed broadcast postemergence		5/26/2020 – Guayule 3 m stand counts and leaf counts 5/28/2020 – Guayule leaf counts 6/4/2020 – Nadir Photographs 6/4/2020 – Sprayed Aim treatments 6/9/2020 – Guayule 3 m stand counts 6/25/2020 – Guayule 3 m stand counts and leaf counts 6/26/2020 – Aim Spray 6/26/2020 – Weed ratings 7/8/2020 – Guayule 3 m stand counts 7/10/2020 – Nadir photographs.
6-2-2020	AIM	Bridgestone B2W	Prowl PPI-flat with field cultivator, Aim sprayed broadcast postemergence		6/1/2020 – Guayule 2 m stand counts 6/1/2020 – Nadir photographs 6/29/2020 – Guayule 2 m stand counts 7/7/2020 – Nadir photographs

Development and Testing of AquaCrop Model:

We have received more data from Bridgestone to begin to incorporate the biomass yield as a function of season into the model by adjusting the growth parameters to account for the non-growth period during the winter. The canopy cover is well modeled at this point.

Development of BioCrop Model:

We have determined that this model is not useful for our purposes, and will put this model on hold to focus on the AquaCrop model.

Guayule Density Trials (Direct-Seeded and Transplant-Established):
Plants were scheduled to be harvested in March but that has been postponed to October 2020.

Range of N and P Application:
Experiment was on hold but it has been restarted because permission to continue greenhouse studies was obtained. (COVID-19 response)

Installation of TDR, Infrared Cameras, and Flowmeter System:
The sensors have been redesigned, and one is working well in a grad student backyard. We are just waiting for cameras to finish the other five. Danielle finished camera calibration. We have switched to Amazon Web Services as our database and web hosting location due to the fact it is much more straightforward than dealing with restrictions on the Engineering server.

Python MySQL WINDS Model Integration with Existing Tools:
We have been focusing on the scientific validation and calibration of the WINDS model within the Excel/VBA program. We continue to calibrate each treatment. It is a lot of work, but it will be worth it in the end. Katterman has calibrated the model for the flood treatment, and is working on the drip treatments, which provide different challenges. Maqsood is calibrating the model for the 2019 guar experiments.

Irrigation Experiments – Guayule and Guar:
Diaa El Shikha processed results for the two year irrigation experiment (in collaboration with all partners). He summarized the results in a paper that is undergoing review by collaborators. The significant results are as follows.

1. Rubber and resin contents (%) decreased with increasing water application rate.
2. Irrigation rate should not exceed 100% of estimated ETc for sandy loam and 75% of ETc in clay soils.
3. The sandy loam soil had much higher rubber yields than the clay soil for both irrigation systems at 100% application rate, but similar yields at 75% application rate

We are continuing to collaborate with Sangu Angadi on guar irrigation experiments at Clovis, New Mexico. Neutron probe and remote sensing measurements are continuing during the third 2020 season, and we are processing the data. It looks like we will have three years of data, with interesting variations between years. While the experiments are Dr. Angadi's, collaborating on the experiments with an irrigation model, is generating excellent results.

Deficit irrigation study (water stress):
Research plans were finalized, and the experiment has been initiated. Nothing new to report.

Other Activities
A new study was initiated by Dr. Grover on response of guar genotypes to salinity. [Stated Research Objective: Evaluating and understanding salinity tolerance mechanism in guar genotypes.] Four diverse guar lines were studied for their salinity tolerance (Electrical Conductivity (E.C. = 16 dS m^{-1}) in a greenhouse lysimeter at the US salinity Laboratory.

Preliminary results show significant variation in salinity tolerance among selected genotypes. Based on four traits analyzed (Shoot biomass, Root biomass, Shoot height and Root length), Matador and PI 268229 are salt-tolerant lines and PI 340261 and PI 537281 salt-sensitive lines (Figures 31-32, 33-34).

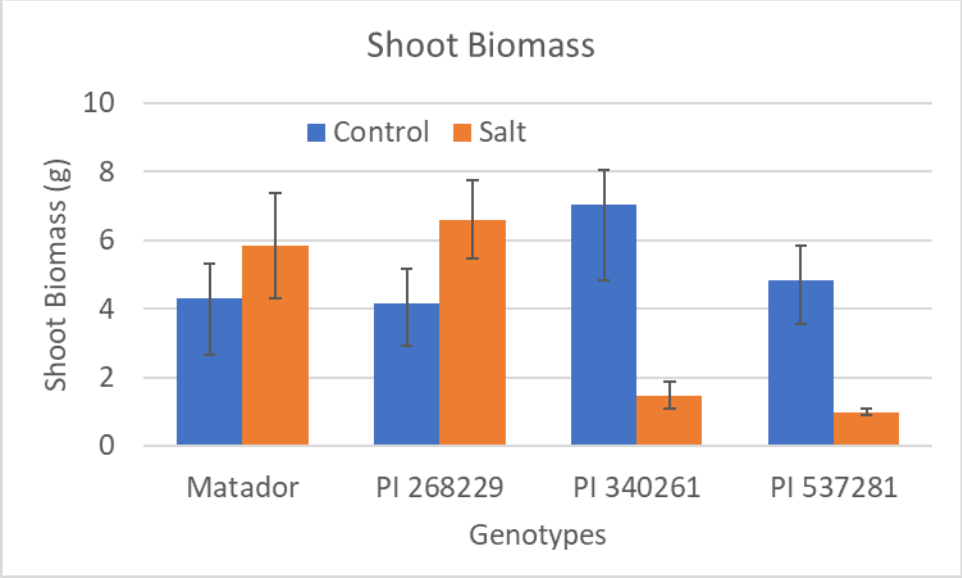

Figure 31. *Comparison among shoot biomasses of different guar genotypes under control and salinity.*

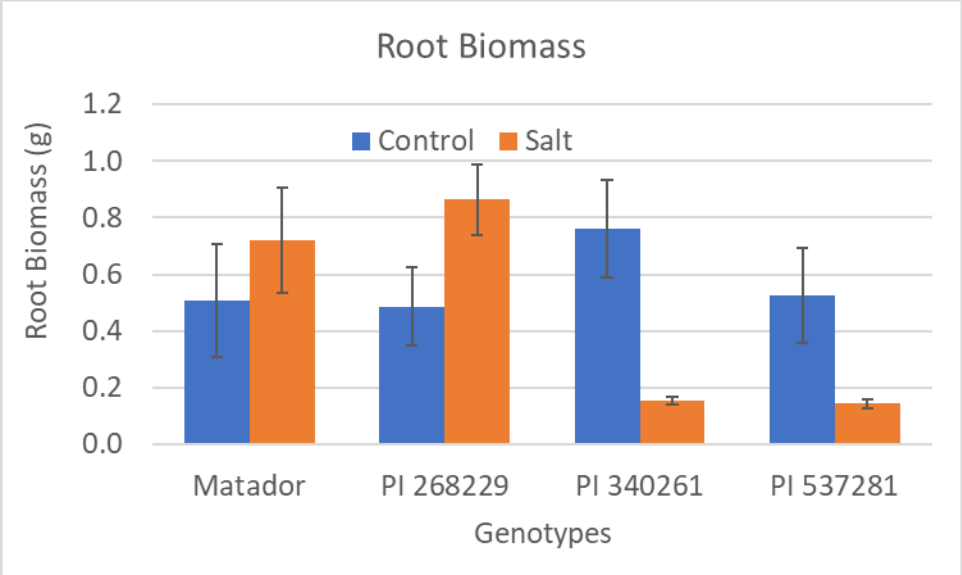

Figure 32. *Comparison among root biomasses of different guar genotypes under control and salinity.*

Genotypes Matador and PI 268229 maintained shoot and root biomasses under salinity, where as genotypes PI340261 and PI 537281 showed significant decrease under salinity.

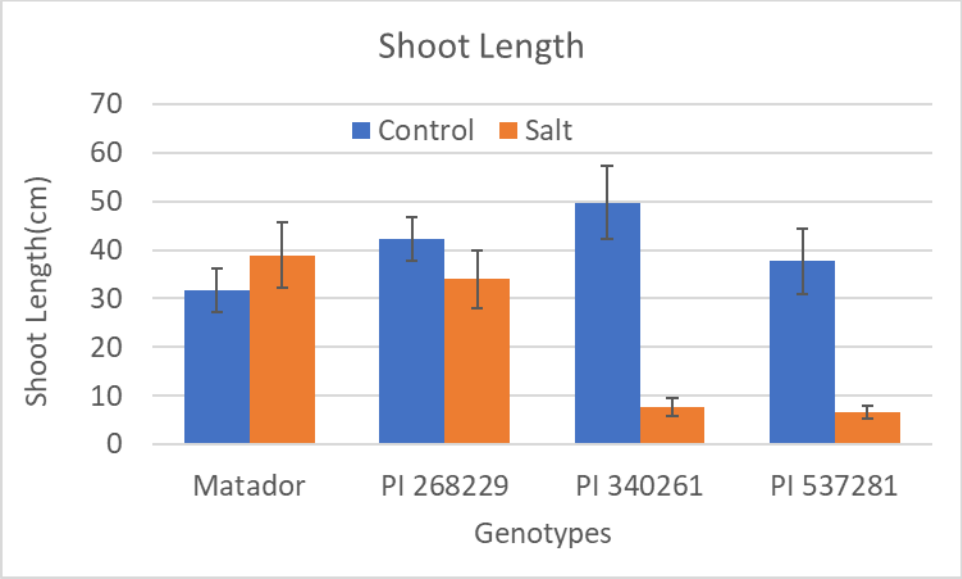

Figure 33. *Comparison of shoot lengths of different guar genotypes under control and salinity.*

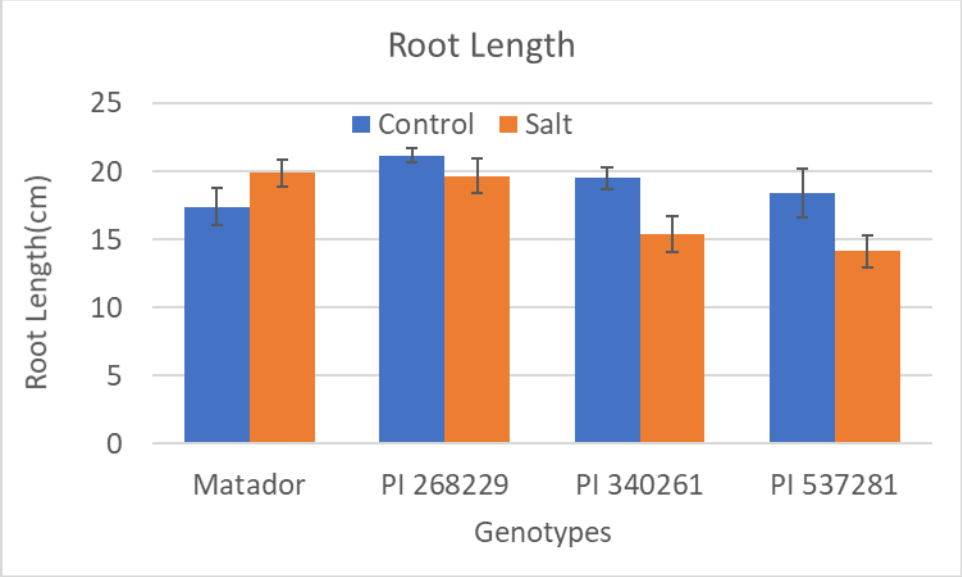

Figure 34. *Comparison of root lengths of different guar genotypes under control and salinity.*

Results showed that the genotypes Matador and PI 268229 maintained shoot and root lengths under salinity, whereas genotypes PI340261 and PI 537281 showed significant decrease under salinity.

Further, expression analysis of a Matador and PI 537281 suggested that differential expression of transporter genes in roots may be the reason for differences in salt tolerance of these two lines (Figure 35).

Matador – Salt tolerant

PI 537281 – Salt sensitive

C – Control

T – Salt treatment

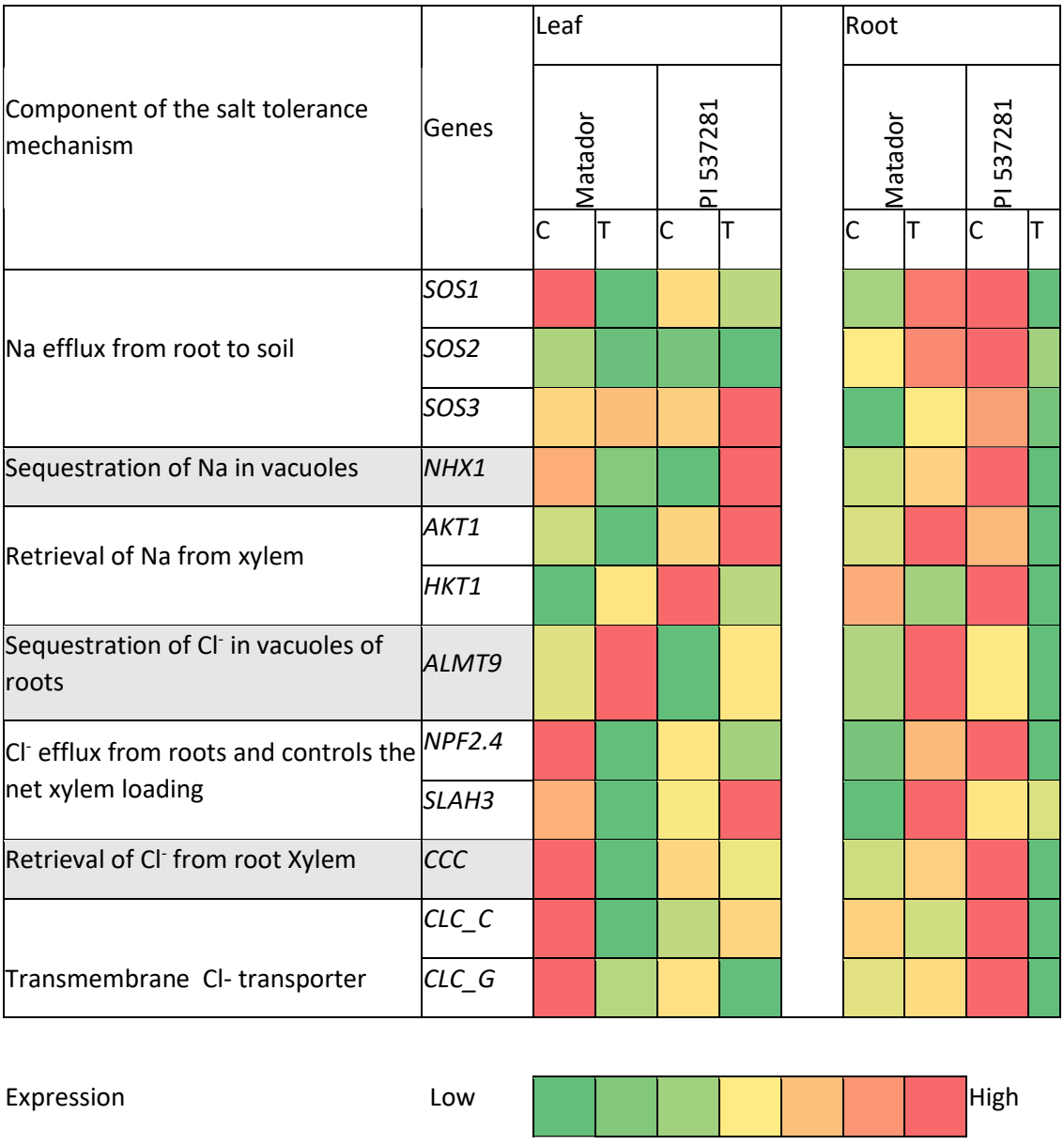

Figure 35. *Normalized gene expression of different guar genotypes under control and salinity.*

The study will continue in 2020, with tissue ion analysis performed, which may help us understand the underlying salt tolerance mechanisms in guar.

For the coming season we are planning to screen 28 diverse guar lines under salinity stress to identify different sources of salinity tolerance and characterize those based on gene expression analysis.

To study global changes in gene expression, we intend to conduct RNA-seq experiment with a most salt-tolerant and a most salt-sensitive guar genotype, which may help in identifying salinity tolerance mechanisms specific to guar.

Objective 5. Develop soil quality and health knowledge critical to environmental sustainability.

Task #	Description of Task	Deliverable	Target Completion Date
1 Maier/ Neilson	Chemical and physical analysis of 108 soil samples	pH, EC, OrgM, NO3-N, P, K, cations, and SAR analysis complete	31 Dec 19
		Soil texture characterization complete	31 Dec 19
		Identify commercial lab for sample processing	1 Feb 20
2 Maier/ Neilson	DNA extraction of soil samples for microbiome analysis	DNA extraction from samples	1 Apr 20
		Amplicon sequencing	1 Apr 20
		Bioinformatics analysis of data generated from amplicon sequencing	1 Jun 20
		Assess spatial/temporal distributions of fungal pathogens on microbial community dataset	1 Jun 20
3 Maier/ Neilson	Soil sample collection for guayule-microbe irrigation study	Collect/archive soil samples for DNA and RNA analysis from 108 samples immediately after harvest	1 Apr 20
4 Maier/ Neilson	Winter dormancy rubber production studies	Chemical analysis of root zone soils collected; analyzed for pH, EC NH_4-N, bioavailable P and Organic C	31 Dec 20
		DNA extraction of guayule root zone samples	31 Oct 20
		Quantification of bacteria and fungi	31 Dec 20
		Amplicon sequencing of bacteria, archaea, and fungi	1 Feb 20

		Statistical analysis of microbial community dynamics and associations	30 Jun 20
5 Maier/ Neilson	Temporal microbiome analysis of community interactions	Sample F50 and F100 treatments of Eloy irrigation trial	1 May 20
		Collect temperature data	1 May 20
		DNA extraction for 215 samples	30 Jun 20
		Amplicon sequencing: bacteria, archaea, fungi	1 Aug 20
		Generate microbial community profiles and network analysis	1 Oct 20

Chemical and Physical Analysis:
Chemical analysis by Brookside Labs is complete for Year 2 soils. Spatial heterogeneity analysis of soil fertility at MAC and Eloy have been presented by Kyle Brown. Year 2 soils will not be analyzed due to issues with NMSU analysis and lack of soils for repeat analysis. Year 3 soils will be analyzed by Brookside when the UA reopens for research

Soil texture analysis is in process. The analysis lab is currently closed and analysis can't be completed until the Shantz Building reopens.

DNA Extraction for Microbiome Analysis:
Kyle Brown is continuing to work on DNA extractions for soil samples collected in the spring of 2018 and 2019 from all irrigation treatments of the MAC and Eloy field trial. He was able to return to the lab in June and has completed most of the extractions described. Extractions are complete for all 2018 soils and for 2019 MAC soils. Eloy 2019 soil extractions are in progress.

Amplicon sequencing complete for 2018 Eloy soil samples. Remaining amplicon sequencing must wait until all 2018 and 2019 samples are extracted to avoid sequencing bias.

Soil sampling for guayule-microbe irrigation study:
Soil samples collected in March 2020 from the Eloy and MAC irrigation trials have been dried and will be ground for soil chemical analysis at Brookside Lab when access to the soil mills is available (access is currently restricted due to the coronavirus).

Winter Dormancy Rubber Production Study:
Further statistical analyses were conducted for the Winter Dormancy study in addition to the results presented in the 2020 Q1 report. Correlations between the relative abundance of individual bacterial and fungal phylotypes in the plant root-zone and plant rubber concentration were evaluated. A greater number of individual phylotypes were strongly correlated with plant rubber content in April (12 bacterial families) than in February (2 bacterial orders, but 0 bacterial families). The significance of the greater number of phylotype-rubber correlations observed in April as compared to February will be discussed with the McMahan research group.

Temporal microbiome analysis of community interactions:

Sampling for the temporal soil microbiome study was completed in Q2. Soil samples from plant root zone were collected at 9 time points between August 2019 and May 2020. The last soil samples for this study were collected on May 5, 2020. Five replicate samples were collected from the Flood 100 treatment at Eloy and either 5 or 30 samples were collected per sample time from the Flood 50 treatment. A total of 240 samples were collected over a 10-month period from Flood 50 and 100 irrigation treatments at the Bridgestone Eloy Research Farm. This experiment will allow an extensive spatio-temporal analysis of the guayule soil microbiome. The objective of this study is to identify a core microbiome of the guayule plant root-zone that is consistent across plant growth stage, field spatial variability, and seasonal environmental variability. The core microbiome is being studied in the 50% irrigation treatment because this irrigation level is most representative of the conditions experienced by the native plant. During Q2, Yongjian Chen conducted an extensive literature review to identify techniques that will allow him to combine the proposed spatial and temporal sample analysis to facilitate the identification of the core microbiome. His goal is to analyze interactions between members of the guayule root-zone microbiome (bacteria, archaea and fungi) in order to differentiate between core and non-core members of the microbiome. This analysis will reduce the immense diversity of the soil microbiome to a “most-wanted” list of microbes that characterize the critical guayule core microbiome. Correlations can then be evaluated between this microbial diversity profile and guayule rubber/resin production and plant health under a range of field management conditions. Yongjian hypothesizes that one could change the plant fitness by manipulating the core guayule microbiome.

CHARACTERIZATIONS & CO-PRODUCTS

Project Coordination: Following group discussions, it was decided in February 2020 to rename this component to “Characterizations & Co-Products” because the tasks associated with post-harvest logistics were moved (a better fit) to the System Performance & Sustainability Component. All of the remaining objectives and tasks are related to biochemical characterization of molecules and identifying possible uses of those molecules or components.

The Characterizations working group meetings are hosted by NMSU once monthly, and led by Dr. Catherine Brewer. During these meetings, progress reports for all component tasks are provided by team members, issues and challenges are discussed for resolution, and specific tasks are integrated where possible. Data exchange is accommodated via a shared access folder online, and meeting minutes are maintained as a reference.

Issues/Risks:
Brewer: At the beginning of June, the Brewer and Holguin groups were able to get permission for a limited return to the research lab. Dehghanizadeh was able to complete the final analyses needed for the algae + guayule bagasse co-HTL samples; Rosalez will continue manuscript preparation for that study when he finishes his MS defense. Dehghanizadeh was able to obtain permission for work in the Urban Entomology lab starting in July, enabling insect repellency studies to continue in Q3.

Before the lab closures due to COVID-19, Dehghanizadeh was able to locate the software needed for one of the instruments that had been missing. We anticipate that he will be able to return to work on rebuilding SFE capabilities in late July. Demonstration of capabilities will likely be delayed until 2021 Q1 due to lab access limitations.

Gunatilaka: As a result of UA mandated COVID-19 response, all laboratory operations had to be halted from March 16, 2020 to June 8, 2020, hindering progress of this project. However, during the closure, the postdoc involved in this project worked from home analyzing research data and preparing reports and manuscripts.

Holguin: COVID-19 guidelines allowing only essential activities to continue has delayed our research activities. We are hopeful to catch up by the end of Q4 (<6-month delay) now that restrictions are lowered and we have increased our on-campus laboratory time.

We previously reported that a gas chromatography (our primary instrument for metabolomics work) was nonfunctional. The parts were ordered but delayed due to COVID-19 restrictions. We anticipate receiving the parts in July. (<6-month delay)

A recent power outage damaged our -80C freezer and in-house nitrogen generator used to support all of the LC/MS unites, CHNOS analyzer, and nitrogen evaporator. The repairs of the nitrogen generator lead to a delay. Repairs are due to be completed early Q4. The -80C freezer will likely need to be replaced. (<6-month delay)

The Holguin lab's laboratory manager overseeing chemical analysis resigned in Q1. We received approval for a replacement and interviews were conducted. A new laboratory manager was hired – Claudia Galvan – who started work in June 2020. (<6-month delay).

Ogden: COVID19 Issues – BioCrop activities: the university is back open to a limited degree and we are progressing on more characterization studies but it is slow. Bridgestone is now reopened to do analysis, but they have had some maintenance issues that should be solved soon so that we can more strategically plan the next phase of the distillation experiments.

Objective 1. Evaluate how seasonality, processing, and storage affect product quality, conversion efficiency, and economics.

Task #	Description of Task	Deliverable	Target Completion Date
1 Holg	Biochemical composition analysis of guayule and respective products	Metabolomics and lipidomic assessment during abiotic stress and adaptation	31 Aug 20
		Generate 2nd manuscript on metabolomics cold adaptation/ pathway regulation	31 Aug 20
		Generate manuscript on high resolution mass spectrometry analysis of guayule resin	31 Aug 20
2 Holg	Biochemical composition analysis of guar and respective products	Develop standard operational methods to characterize polysaccharide composition of purified guar gum	31 Aug 20
3 Holg	Analytical evaluation of thermochemical conversion products	Complete composition information and sample extracts	31 Aug 20
		Contribute to manuscripts	31 Aug 20

Guayule Biochemical Composition Analysis:
Mr. Sergei Shalygin has been assigned to work on the resins along with Claudia Galvan, Dr. Jarvis and Mr. Dehghanizadeh. We were still in the optimization stage of our new computational and data acquisition platforms when our COVID-19 guidelines were implemented. Additionally, chloroform, methanol, acetone method for resin fractionation was chosen for further HPCL analysis, unfortunately due to damage to our nitrogen generator from a recent power outage all instrumental activities were postponed including CHNOS analysis.

Guar Biochemical Composition Analysis:
This task has been completed; SBAR Highlight posted 3 April 2020.

Analytical Evaluation of Thermochemical Conversion Products:

Metabolomics and Biochemical Analysis – We have continued our work with Dr. Von Mark V. Cruz and Dr. David Dierig on characterization of cold adaptation of guayule leaf material. Ms. Ujala Sehar had begun processing the metabolomic samples and work was largely delayed due to COVID-19 guidelines. The pathway analyses of the guayule metabolic biomarkers were completed. The metabolic biomarkers were classified into functional categories.

The figures for the associated manuscript were completed. The guayule metabolome from this research will be made available to the scientific community this Summer, and the manuscript is on its final writing steps and will also be submitted to the Industrial Crops and Products Journal this Summer. This work has been delayed due to a lack in computational resources used to write this manuscript at home during the COVID-19 pandemic.

Publications – Ms. Kelly Laje has addressed co-author edits and comments for the final draft publication "Natural Products in the Desert Southwest: Guayule (*Parthenium argentatum*) and Guar (*Cyamopsis tetragonolobus*)." The document has been formatted according to American Phytopathological Society guidelines for authors, and a final look-over the paper is underway to ensure all standards and guidelines are met. Initially, we had hoped to have the paper submitted in April, 2020; however, we have experienced some setbacks with meeting delays and work access due to the COVID-19 pandemic. Many restrictions that previously hindered our forward progress have been lifted and we project this publication will be ready for submission to the "Plant Management Network" by the end of July, 2020.

Objective 2. Demonstrate feasibility of farm to fuel conversion of bagasse.

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Prepare 2 manuscripts on guayule/guar bagasse composition, biomass-to-conversion method matching (HTL product yields)	Manuscripts prepared Manuscripts submitted for peer-review process	31 Aug 20 31 Aug 20

Manuscript Preparation:
A data article on guayule resin chemistry was accepted for publication in *Data-in-Brief*. Brewer and Cheng received permission to submit a review article on biochemical conversion of high-protein, high-lignin feedstocks to *Renewable & Sustainable Energy Reviews*; submission is expected in July.

Bayat, Brewer, and Cheng also continued work on the third of the three conversion reviews: this one focused on low-cost feedstocks for biofuels, especially food waste and residues not suitable for animal feeds/soils due to the presence of toxic compounds.

Rosalez continued his work on his MS thesis on algae + guayule co-HTL conversion, scheduled now for an early fall defense due to lab closure delays in getting the last analysis data.

Objective 3. Identify economic co-products in guayule and guar, e.g., biologically active components.

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Prepare manuscripts on low-cost biomass conversion methods review, and co-HTL of guayule bagasse and algae.	Prepare manuscript; Submit manuscript to peer review journal	31 Mar 20
2 Brewer	Perform separations and fraction characterization of guayule resin	Purchase supercritical solvent extraction system Perform liquid-liquid, accelerated, and filtration separations Prepare manuscript of guayule resin separation	31 Aug 20 31 Aug 20 31 Aug 20
3 Gunat	Chemical and microbial transformations	Develop chemical and/or microbial methods for the conversion of guayule by-products into value-added products	31 Dec 19
4 Gunat	Evaluate major metabolites of guayule	Evaluate transformation products of argentatins A, B, C for potential anticancer/ antimicrobial activities	30 Apr 20
5 Gunat	Isolate and characterize major metabolites of guayule terpene solution	Identify metabolites within solution that can be converted to value-added products	31 Jul 20
6 Ogden	Evaluation of major fractions of guayule resin	Recommendation of potential products that can be separated from resin fractions	31 Aug 20
7 Ogden	Cost analysis of potential resin products	Initial incorporation of resin products into TEA	31 Aug 20

Prepare Manuscript on Low-Cost Biomass Conversion Methods:

Dehghanizadeh continued work with the Quinn group at CSU on the guayule resin composition and application review manuscript with economic information to help down-select target value-added applications. Permission was received from the editor of *Industrial Crops & Products* to submit the review. Submission is expected in the new few weeks. Dehghanizadeh prepared and recorded a presentation (with conference proceeding paper) based on the review article that will be shown at the ASABE Annual International Meeting (now virtual) on July 13-15. He also had an abstract accepted for a presentation on guayule resin separation and chemistry at the AICHE Annual Meeting.

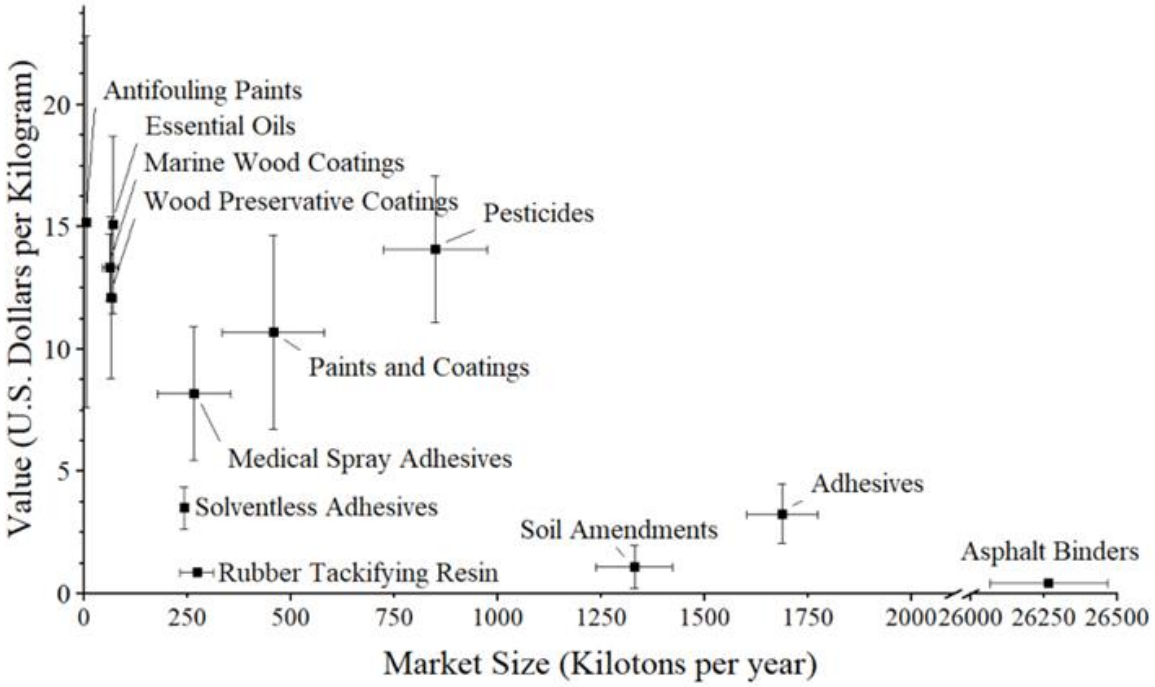

Figure 36. *Potential guayule resin applications based on material selling price and market size based on resin literature (used to guide application experiments).*

Separations and Fraction Characterization of Guayule Resin:
Dehghanizadeh and Knagg, in collaboration with Romero Alvero's group at NMSU, created a design plan for the next resin fraction insect repellency tests for the summer/fall on Turkestan cockroaches. The preliminary results showed around 80% repellency for terpene-rich extracts. These promising results lead us to use the advanced techniques like tracking camera, to find the accurate behavior of insects towards guayule resin extracts.

Photo 5. *Urban entomology repellency experiment set-up with Turkestan cockroaches.*

Photo 6. *Repellency test of guayule resin extracts on Turkestan cockroaches.*

Knagg successfully completed a undergraduate honors thesis on guayule resin applications and the results of the cockroach studies before the lab closures.

Chemical and Microbial Transformations:

As guayulin B is not known to have any useful biological activity, conversion of it into coproducts with potential biological activity was initiated. To this end, guayulin B was subjected to careful hydrolysis with sodium cyanide (NaCN) in MeOH at 60 ^{o}C) to yield its deanisyl analogue (**1**) in 55% yield.

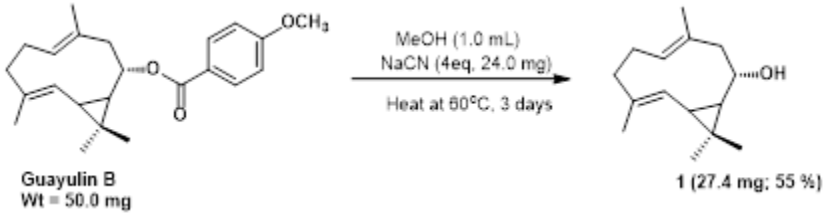

Figure 37. *Hydrolysis of guayulin B.*

Semi-synthesis of benzylidene intermediates (**2**-**4**) of argentatins A, B and C by Claisen-Schmidt condensation was repeated to obtain material for spectroscopic characterization required to be

included in the manuscript on pyrimidine analogues of argentatins A, B and C which is currently under preparation to be submitted to the journal, *Bioorganic and Medicinal Chemistry*.

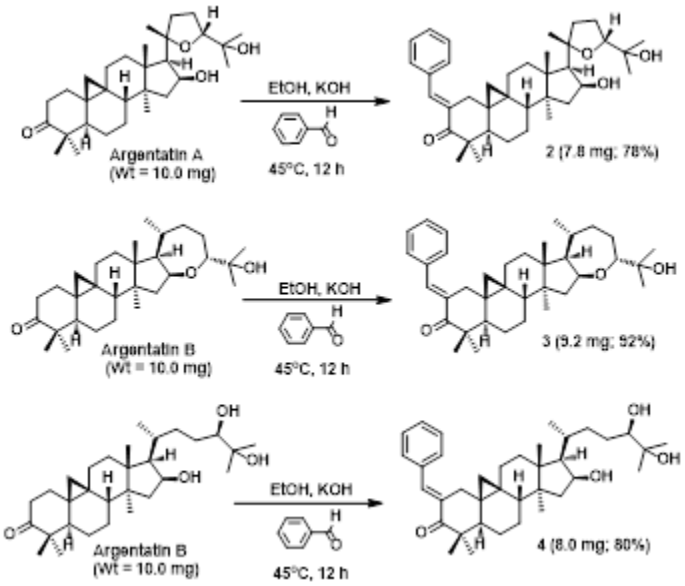

Figure 38. *Semi-synthesis of benzylidene intermediates (2, 3 and 4) of argentatins A, B and C.*

Evaluate Major Metabolites of Guayule:
Nothing new to report.

Isolate and Characterize Major Metabolites of Guayule Terpene Solution:
Nothing new to report.

Fractions of Guayule Resin:
We study the project sustainability and the potential of high-value-added products obtained from guayule resin. Sarocha is working on writing manuscripts related to adhesives and particle board from guayule resin and bagasse. The IP should be filled with Tech Launch this quarter. We have started that process. Examples of the characterization of guayule resin are shown in the figures below.

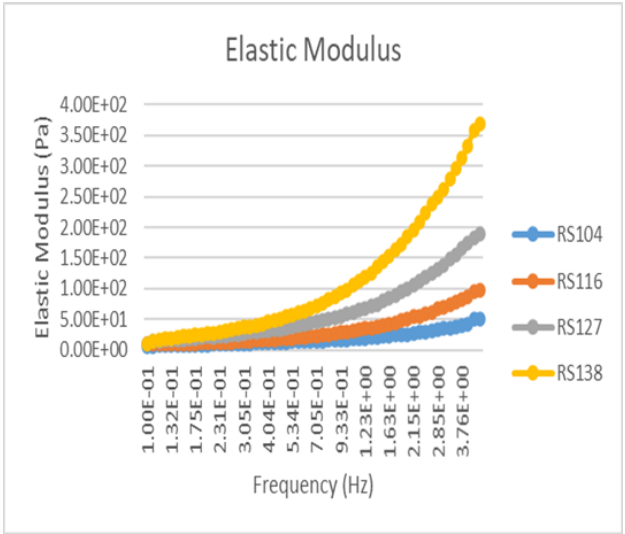

Figure 39. *Adhesive properties (elasticity) of guayule resin.*

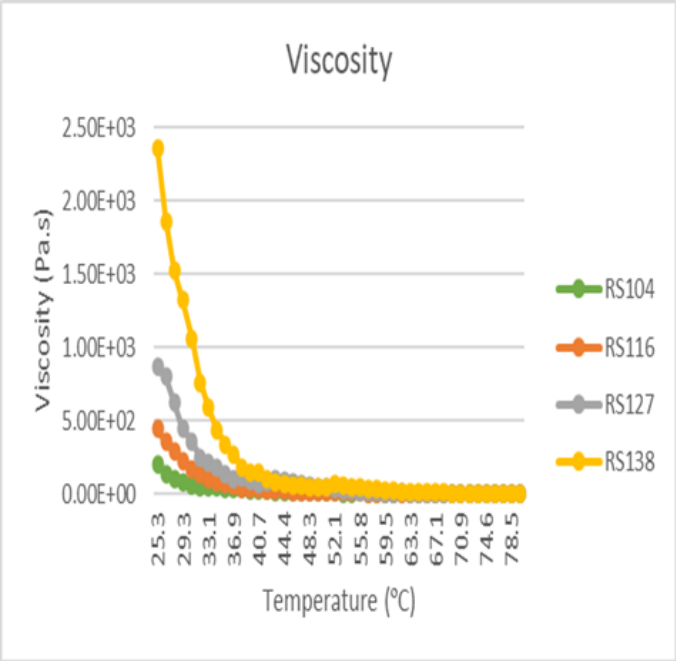

Figure 40. *Viscosity of guayule resin at various temperatures.*

Cost Analysis of Potential Resin Products:

Andrew has completed multiple distillations. Graphs of the results are below which are plots of distillation time versus temperature under 0.32 and 0.20 psi. Eleven and nine different respective fractions were obtained from the resin with volumes ranging from 0.3 to 9 mL with the largest fraction being primarily solvent.

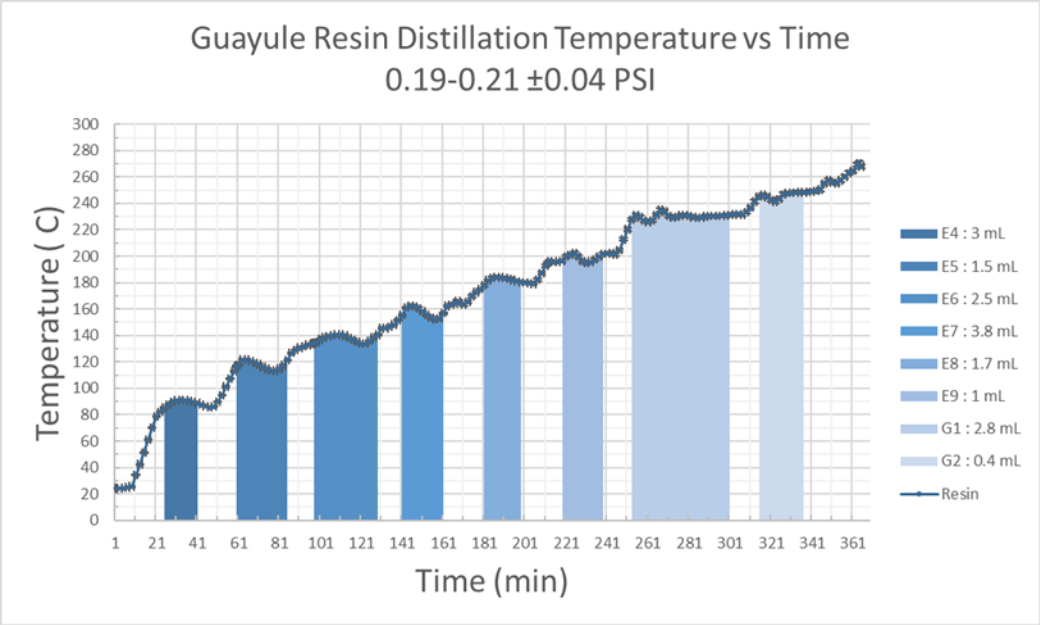

Figure 41. *Distillation of guayule resin at low temperature.*

Bridgestone will analyze the collected fractions for content and purity when their lab reopens. A distillation using the fractionating column did not provide expected additional fractions; a scale up procedure to use more resin mass is being developed. Collaboration with Jason Quinn and Catie Brewer on the incorporation into TEA is going well.

SYSTEM PERFORMANCE & SUSTAINABILITY

Project Coordination: Colorado State University (Dr. Jason Quinn) leads the fortnightly working group webinar/phone calls. The meetings are leveraged to ensure all team members are on schedule and work can seamlessly integrate across institutions. The structure for the team meetings has been alternating between team updates and individual deep-dive presentations.

Standing agenda item include COVID-19, and field trial data integration which is currently being led by CSM. COVID-19 has had minimal impact on the CSU and sustainability team in general in terms of research productivity. The impacts of COVID for the sustainability team are limited to other SBAR Teams' members as data collection and laboratory work have been impacted.

The focus this quarter has been:

- Revisions to manuscript on guayule
- Supporting manuscripts and research in the area of co-products (C. Brewer)
- Refinement of the integrated model
- Model integration across the sustainability team focused on validation and improved fidelity
- Submission of a publication on guar
- Working with Guar Resources
- Development and moderation of a sustainability team meeting on a bi-monthly basis in support of model integration and data integration
- Resin economic modeling with integrating foundational modeling into the integrated model

All notes and presentation materials are maintained in a community workspace available to all partners for future reference.

Issues/Risks:
Fan: Although our work is focused on modeling and optimization, the inputs for the model play a crucial role in the results. Unfortunately, because of the COVID-19, there is no direct face-to-face talks with our industrial partners. Although we tried to reach some industrial partner many times, some feedback has not been received yet. To handle this issue, an extensive literature review and online search for publicly available information is being performed. Additionally, meetings with other SBAR researchers and industry partners are scheduled to request concise information and email follow-ups are also helpful.

Landis: Interviews of field trial PIs is critical to support the integration of 'likelihood' of datasets into the integrated model. Interview protocol has been established, and 2 interviews are complete. Interviews with the leaders of the remaining field trials are being scheduled.

Complete field data collection – data from one PI is still missing (Bill McCloskey). Otherwise, next steps in data collection (which will be prompted during interviews), are to collect refined data about equipment usage and field management practices for the TEA. In addition, as new field trials are completed, we will need to collect the new data and update the integrated model accordingly.

Quinn: CSM continues to be a risk to the project.

Seavert: Depending on the COVID-19 pandemic, meeting with producers may need to be postponed in this reporting year.

Objective 1. Develop a scalable engineering process model for crop production and processing that is coupled with Techno-Economic Analysis (TEA) and Life Cycle Analysis (LCA) to understand the economic impact to rural communities through input-output methods.

Task #	Description of Task	Deliverable	Target Completion Date
1 Gutierr	Functional integration of economic analysis into system model	Gather information for farm level scenarios using different avg. farm sizes, irrigation, and acreages	31 Aug 20
		Conduct input/output analysis of system model results	31 Aug 20
		Validate preliminary analysis for farm production and profitability	31 Aug 20
		Generate publication on the economic analysis for guar and guayule	31 Aug 20
2 Gutierr	Initiate development/testing of online producer systems model	Create online tool for evaluating guar/guayule alternative crops	31 Mar 20
3 Landis	Field data transfer	Develop SOP/protocol for transferring field data to LCA team in useful formats	31 Dec 19
4 Landis	LCA first order model	Journal publication submitted for 1st order LCA	31 Mar 20
5 Landis	Integrate current field data into LCA/TEA model	Update LCA/TEA model inputs with field data; identify new scenarios	31 Aug 20
		Manuscript generated and submitted to peer review journal	31 Dec 20
6 Landis	Sensitivity and scenario analysis	LCA Scenario Analysis complete	31 Aug 20
7 Quinn	Techno-economic and Life Cycle Assessment results	Update/finalize economic and environmental impact results	1 Aug 19
8 Quinn	Data integration	Integrate experimental data into foundational processing model	31 Aug 20
9 Seav	Validated integrated model	Update and incorporate new information under various scenarios	31 Aug 20

10 Seav	Diversify integrated model for broader audience	Incorporate returns/costs of additional crops into integrated model	31 Aug 20
11 Teeg	Facilitate working agreement between Tribal Farms and Bridgestone to establish experimental plots	Signed agreement established between Gila River Farms and Bridgestone Experimental plots established on Tribal lands	31 Aug 20 31 Aug 20
12 Teeg	Validated integrated model	Update and incorporate new information under various scenarios	31 Aug 20

Functional Integration of Economic Analysis into System Model:
Nothing new to report.

Online Producer Systems Model:
Nothing new to report.

Field Data Transfer:
This Task is ongoing as we will integrate any and all new data from field trials as it becomes available. Field Trial Data collected includes: (Guar: Angadi/2018 & 2019; Idowu/2019; Grover/2019; Ray 2019 – Guayule: Dierig/2020; Wang/2020; Ray/2019). The datasets include: (Irrigation, Nitrogen and Phosphorus, Herbicide, Insecticide, Tillage, Seed Rate, Harvest, Yield, some equipment & management practices [not complete]).

First Order LCA Model:
Nothing new to report.

Integrate Field Data into LCA/TEA Model:
The available field data has been integrated into the LCA model. Mealing gave a presentation to the sustainability team on updated progress of field data integration (June 25, 2020). Four of the guar field trials have been fully integrated into the systems model. Capability to choose different field trial scenarios has been implemented and results figures are populated for each scenario. As data continues to be collected, integration continues as well. Ability to specify data probability (likely, unlikely, optimistic) is in progress via interviews with the field trial PIs. Statistical and scenario analysis of the datasets and results is underway. Next steps are to collect the details of equipment and management practices from the field trials.

Sensitivity and Scenario Analysis for Integrated Model
Monte Carlo Analysis modeling has begun: probability distributions for the field data inputs are being defined using best-fit statistical methods; this work is in progress. Next quarter, distributions will be defined for the detailed inputs tabs in the integrated model and Monte Carlo Analysis will be enabled throughout the model.

Techno-economic and Life Cycle Assessment Results:
A variety of efforts were pursued as a part of this task with a summary presented below:

Model Integration: CSU continues to lead the integration effort with the development of a modeling framework to support the integration of the research across all research groups. This quarter, efforts have been focused on working with Mealing at CSM to enable seamless integration of field trial data into the integrated model. In addition, this quarter has resulted in dramatic changes/updates to the guar model based on working with industry and experimentalists on the SBAR team. CSU continues to lead the LCA and TEA components of the modeling work.

Guayule: The integrated model is currently being updated with the resin and bagasse to fuels modeling work. The sub-process models of these unit process operations have been constructed outside the integrated model. Results have been verified with these unit-process operations being added to the integrated model. This process has been started and will be completed prior to the all hands meeting. In addition, the CSU team is continuing to work with the transportation optimization team to ensure inputs to the optimization work are harmonized with the integrated model.

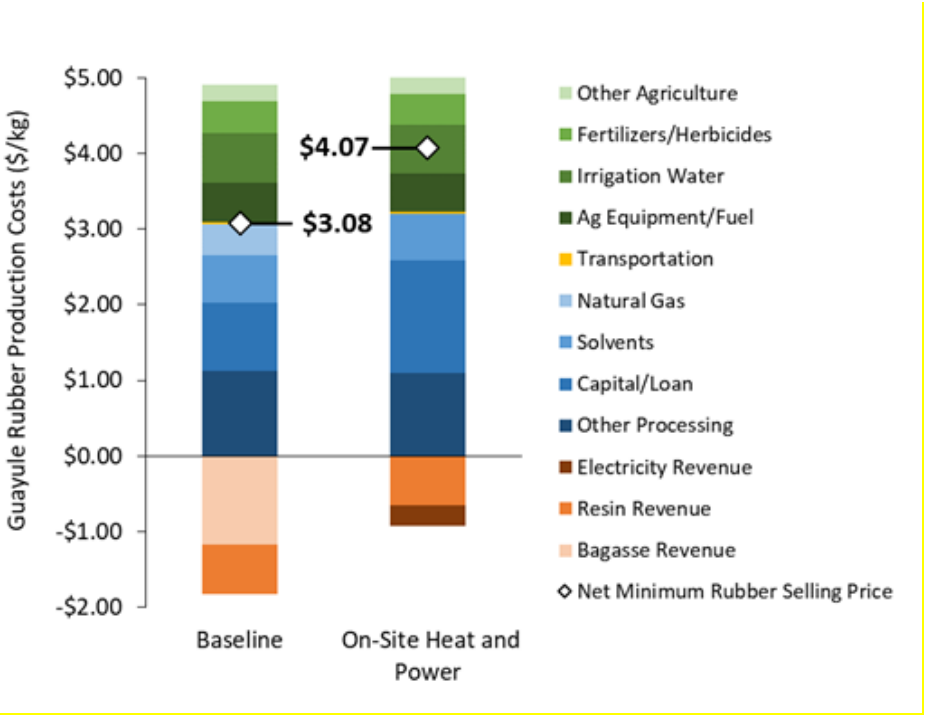

Figure 42. *TEA and LCA results generated for guayule under two scenarios.*

Resin Work: This quarter, the CSU team continued to dedicate work on understanding the impact of improving the resin value. This has included refining the modeling work that is determining the value of the resin and the market sizes of different potential products. In addition, as detailed above, the resin work is being added to the integrated model.

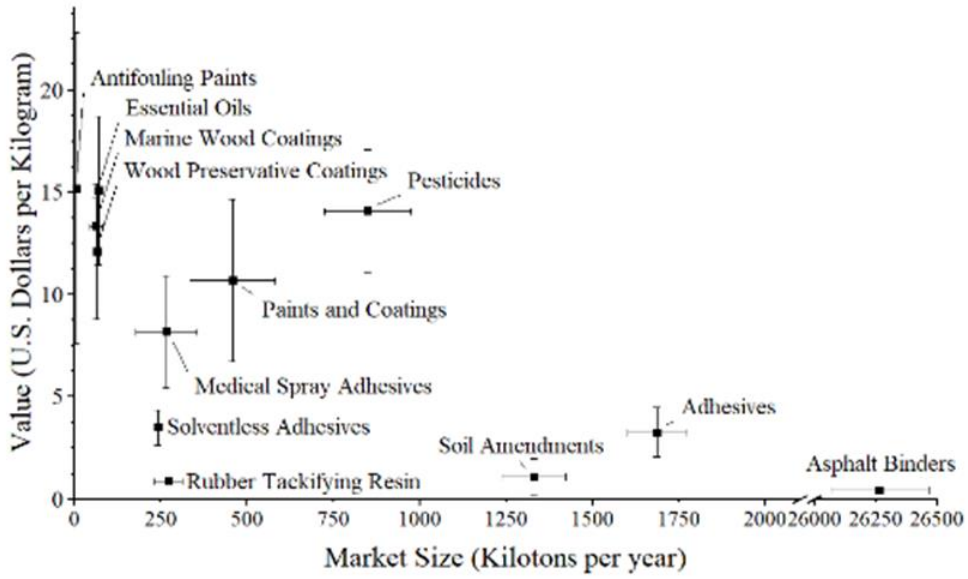

Figure 43. *Potential guayule co-products and their estimated market values.*

Guar: Work this quarter has focused on finalizing the manuscript and submitting it for peer review. This has included directly working with agricultural researchers and developing scenarios that represent field trials being performed as a part of the SBAR team. The results from updating the guar model have dramatically changed results. The primary change is the result of better understanding the actual operations of a guar farm. This has included updating the nutrient inputs, irrigation requirements and farm equipment use. The manuscript that was submitted now includes scenarios that are representative of field trial data collected from SBAR. Additionally, most recent work has focused on developing uncertainty analysis within the guar model using Monte Carlo analysis.

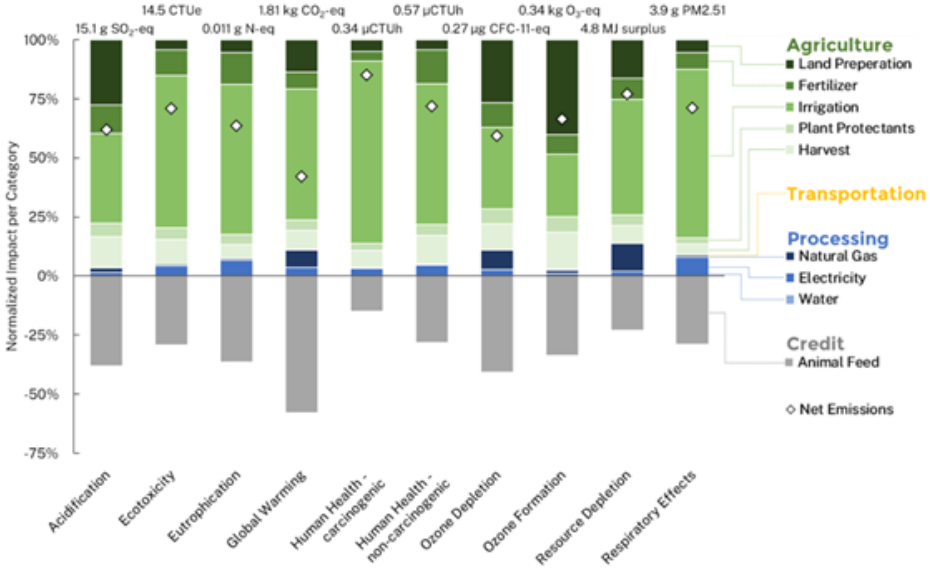

Figure 44. *Preliminary TEA results for guar.*

Data Integration:
Experimental data integration represents a critical need for the sustainability team. CSU continues to support CSM with seamless integration of data into the integrated model. Care is being used to ensure raw agricultural data is not accidently disseminated by imbedding data in uncertainty distributions.

Validated Integrated Model:
Validating machine operations and continuity of output between guar and guayule models. Working with others in the SUS team to validate model with research data and reasonable outputs for publications.

Diversify Integrated Model for Broader Audience:
Continue to update the integrated models with incorporating the costs and returns of fallow and three hemp crops – oil, seed, and fiber.

Facilitate and Foster Relationship between Tribal Farms and Bridgestone:
Continuing to assist in securing experimental plots on at least two tribal farms. 1) Connect Bridgestone and CRIT farms for experimental acreage agreement, establish introduction meeting and started contract negotiations 2) Connecting Bridgestone and Fort McDowell Farm or Ak Chin Farms for experimental acreage agreement. Started the conversation, but still trying to establish an agreement that will work for both parties. This is a long process and will take some time to complete.

Validated Integrated Model:
Continue enhancement to the farm level scenarios using different average farm sizes, irrigation technologies, and add in different crops into the mix for both New Mexico and Arizona.

Other Activities:
The CSU team is supporting various other SBAR activities like supporting Dr. Brewer in the development of a review article related to guayule resin. The CSU team is working with Dr. Brewer's group to develop discussion in the review paper NMSU is leading.

Objective 2. Integrate regionally appropriate metrics and combine results from SBAR-developed data into sustainability models to provide a path to commercialization of biofuels and bioproducts.

Task #	Description of Task	Deliverable	Target Completion Date
1 Quinn	Downstream process modeling	Integrate downstream process modeling	1 Nov 20
2 Quinn	Scenario analysis	Generate results of scenario analysis	1 Feb 20 28 Feb 20

		Present results of scenario analysis at conferences for feedback	
3 Quinn	Stochastic modeling	Evaluate system at a system level through Monte Carlo sensitivity modeling	30 Jun 20

Downstream Process Modeling
Research continues as planned; nothing new to report.

Scenario Analysis:
Research continues as planned; nothing new to report.

Stochastic Modeling"
Research continues as planned; nothing new to report.

Objective 3. Interface with regional growers to de-risk US production of guayule and guar while evaluating social impacts.

Task #	Description of Task	Deliverable	Target Completion Date
1 Landis	Clarify social sustainability metrics	Develop overview of sustainability tools and list of potential metrics Generate publication/presentation for conference proceedings	30 Nov 19 30 Apr 20
2 Landis	Social sustainability	Collect data from annual SBAR meeting Data analyzed and report drafted	31 Dec 19 31 Aug 20

Clarify Social Sustainability Metrics:
Review to identify appropriate social categories and data indicators of SBAR areas of interest is complete; one of Mealing's thesis committee members asked her to add one new framework to the analysis; once this addition is completed the updated manuscript will be distributed to the SBAR team for review. A manuscript draft is currently under review with Drs. Landis and Smith (thesis committee member, not an SBAR team member).

Social Sustainability:
Nothing new to report.

Objective 4. Develop and optimize system-level logistics models for demand-driven harvesting.

Task #	Description of Task	Deliverable	Target Completion Date
1 Fan	Comprehensive sustainability and economics analysis	Conference presentation Manuscript submitted to peer review journal	31 Mar 20 31 Mar 20
2 Fan	Apply integer optimization approaches to design smart farm production plan/ scheduling	Manuscript submitted to conference/ journal summarizing research	31 Aug 20
3 Fan	System-level model/algorithm generation for decision support for guar and guayule	Preliminary results shared during project component team meetings Data/model/algorithm shared for Yr4 research (integration of 3 decision modules)	31 Aug 20 31 Aug 20

Comprehensive Sustainability and Regional Economics Analysis:
In Quarter 2 of 2020, the inputs of the model for optimal decision of facility location and transportation were modified based on the feedback from the SBAR UA Research Group Meeting and the SBAR SUS Group Meeting. Results were updated as presented by Figure 45 and Figure 46. The structure and wording of the paper “Integration Environmental and Social Impacts into Optimal Design of Guayule and Guar Supply Chains” were highly improved to be submitted to a journal for publication.

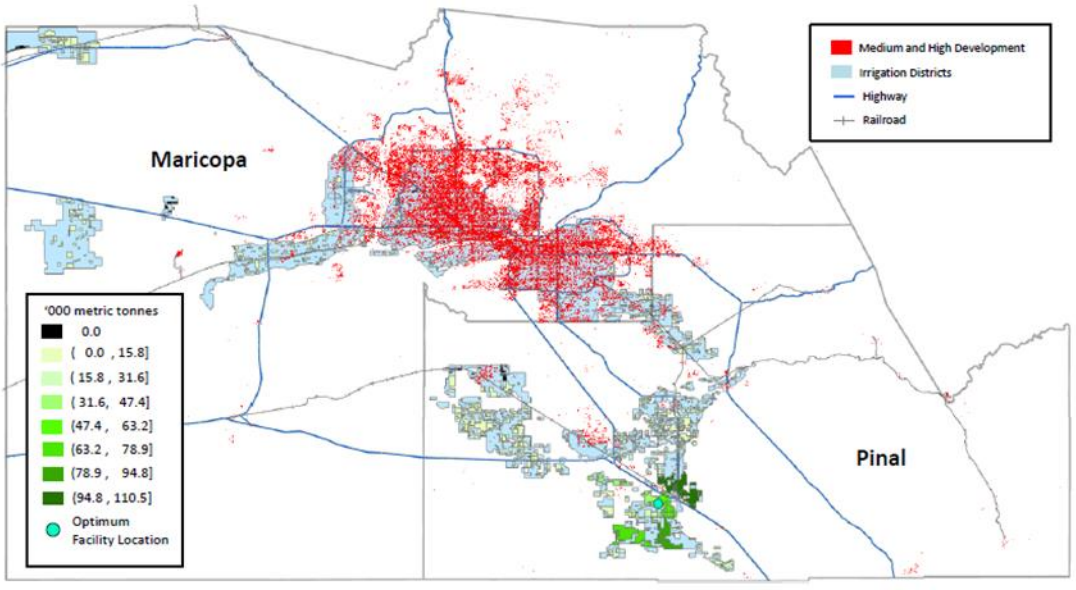

Figure 45. *Expected guayule productivity from Maricopa and Pinal counties' (Arizona) CGO farms.*

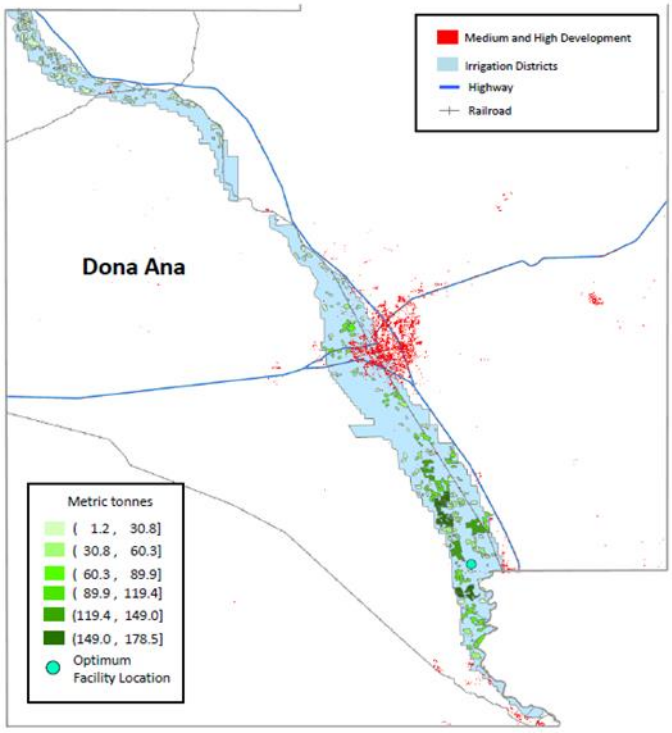

Figure 46. *Expected guar productivity from Dona Ana county's (New Mexico) CGO farms.*

We have continued to gather information from the "Future Guar Area" and Arizona as shown in Figure 47.

Information has been gathered from the following counties:

- In Arizona – Cochise, Maricopa, Pinal and Yuma counties.
- In New Mexico – Curry, Dona Ana, Quay, and Roosevelt counties.
- In Texas – almost 50 counties from Archer, Armstrong, and Bailey to Wichita, Wilbarger, and Yoakum.

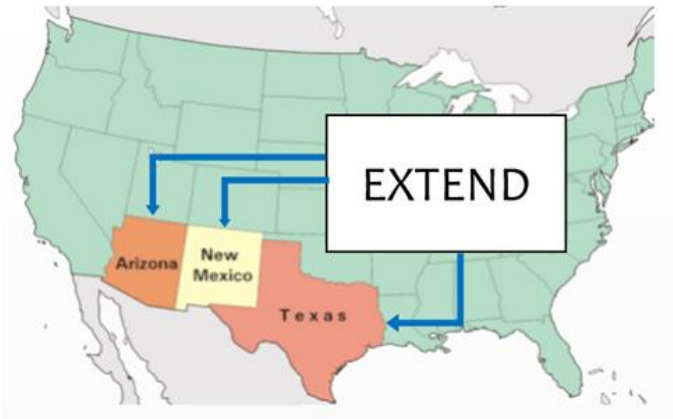

Figure 47. *CGO farms in future guar area and Arizona.*

Integer Optimization Approaches for Smart Farm Production/Scheduling:
This research will be applied from two different angles: the farmer's perspective, and the processing facility's perspective. A model for the smart farm production and schedule from the farmer's perspective has been designed and its coding its coding has been complete to start its debugging and testing process. Information has been gathered for a case study from guayule and guar farms in Arizona and New Mexico. A first draft of the model for the processing facility's perspective is being defined.

System-level Model/Algorithm for Decision Support:
A literature review is being performed to identify the best alternative to integrate all the models into one. All optimization models are coded using the programming language C++, the solver CPLEX, and the high-performance computing (HPC) Ocelote or SIE server from the University of Arizona. Integrating platform options are being analyzed to identify the compatibility with the developed codes.

EXTENSION & OUTREACH

Project Coordination: Dr. O. John Idowu (New Mexico State University) and Blase Evancho (University of Arizona) continue to serve as the co-leads for the Extension & Outreach working team. When the larger Education and Extension & Outreach components jointly meet, Dr. Idowu and Evancho work with Dr. Chavarria to draft meeting agendas. Cara Duncan Shopa (UA) has been tasked with coordinating meeting details and ensuring that notes are captured and maintained in the Box folder for future access/reference.

The Extension & Outreach team has two main foci – youth development (through 4-H activities and STEM mini-camps), and grower education/outreach. These two sub-groups meet at least once per month to discuss tasks and to improve component integration. The combined Education and Extension & Outreach teams meet once monthly to provide updates and address larger concerns regarding over-arching tasks that facilitates seamless project implementation in Arizona and New Mexico.

Issues/Risks:
Angadi: During the quarter, Dr. Sultan Begna, Research Scientist assisting my program left for a better job. Mr. Jagdeep Singh graduated and moved on to another university for Ph.D. I am unable to hire a new graduate student, as COVID-19 and visa restrictions have limited availability of qualified graduate students. Lack of labor power and restrictions imposed by the university/state have delayed many of my projects. Some projects were started with special permission from the Vice-president for Research, NMSU. Some of them will not happen until next year.

Guar outreach was affected COVID-19 pandemic. Field days, farmer visits, photos and video development, demonstration on farmer's field will be postponed until next field season. However, all our field-based activities are doing good and the generated data will be summarized into extension publications next year.

Fields: There have continued to be changes to nearly all planned EEO activities over the past quarter as a result of the COVID pandemic. I have been able to shift my focus to different aspects of the evaluation, including conducting a number of interviews with teachers, fellows and staff as well as reviewing curricular artifacts and working collaboratively with teams as they re-evaluate their plans for the coming months and therefore their evaluation needs change. The final evaluation product for this year may look slightly different than originally intended due to the lack of 'participant data' (i.e. from summer campers or newly recruited teachers) but rather focused on a more in-depth understanding of the most and least valuable aspects of the activities to date.

Grover: Due to the current COVID pandemic, the farmer field demonstration was postponed until next growing season as discussed and agreed within the SBAR grower-focused extension team.

Idowu: We were unable to conduct on-farm, farmer managed trials this year because of the COVID-19 pandemic. We were also not able to conduct extra tabling events that we normally do during summer meetings, since all of these meetings were cancelled in NM due to coronavirus

pandemic. All the in-person field days scheduled for the fall have been cancelled. These issues have the potential of limiting the number of our contacts during 2020. There is a plan being explored to conduct virtual field days at some locations in NM, but the plan is not yet certain.

There was a slight modification in the scope of work related to the release intervals of the Extension & Outreach Newsletter. The frequency was changed from 3 to 2 newsletters per year. This was to allow for significant deliverables to be generated in between newsletter releases.

Morris: We have endured a roughly three-month delay to curriculum, ambassador roll out, and volunteer training. This is due to COVID-19 prevention causing the 4-H program to shift virtual. We needed to adapt non-SBAR programming to virtual platforms to maintain overall program momentum. This reduced the ability of our committees to work on curriculum adaptation as those staff were focused on adjusting their programs. Our planned Greenhouse Camp has been delayed to the fall in hopes of being able to work in person with youth. Despite this setback we supplanted it in the short-term with additional STEM virtual camps that have recruited and trained youth and volunteer leaders preparing them for the SBAR volunteer and STEM ambassador programs.

While these setbacks have been frustrating, we are turning them into positives with increased momentum on STEM virtual programming and through building a stronger partnership with the SBAR Education Team.

Rock: On March 30th the Governor issued a stay at home order due to health concerns related to COVID-19. Accordingly, the University of Arizona has also issued specific guidance eliminating personal contact by all University students, staff, and faculty and halting all field and laboratory operations in which personal protection cannot be ensured. Currently, we do not have guidance on an approximate "all clear" date where we can return to normal operations.

Because our grant objectives specifically target in-person training and education for student interns, our project team is essentially at a standstill. Additionally, the University guidance is that we are to cancel all summer-based programs through July. Because this would essentially cut our interns short of the required time, and because of our uncertain future, we can’t in good faith offer opportunities to students for Summer 2020.

We have worked with the project PI to postpone the intern experiences to 2021. This would allow our research and extension team to re-schedule interns for semesters when faculty, staff, and students return to campus, and allow the project team to fulfill remaining project objectives. This of course may change based on University guidance in coming months as well as student availability.

Teegerstrom: Future work is dependent on COVID-19 restrictions and available programming efforts. However, we are still exploring online options, but it now looking into the fall for completion of tasks.

Objective 1. Produce Extension bulletins and web materials to inform growers of agronomic and irrigation requirements.

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Guar photographs and videos	Obtain photographs of guar growth stages Create videos of guar germination and growth Provide photos and videos for publication	31 Aug 20 31 Aug 20 31 Aug 20
2 Angadi	Guar agronomy research	Gather/analyze data; develop peer-reviewed article on N and P fertilization study Train graduate students in guar agronomic management	31 Aug 20 31 Aug 20
3 Angadi	Guar critical stage irrigation study	Produce report on guar crop growth based on irrigation management	31 Aug 20
4 Evan	Produce guayule newsletter articles	At least 2 guayule articles drafted and published – targeting AZ growers	31 Aug 20
5 Evan	Develop outreach documents for guayule	Produce a USDA Plant Guide for guayule in Arizona	31 Aug 20
6 Fields	Design/schedule evaluation tools, protocols, and metrics for all Extension & Outreach activities	Fall tools developed/refined; evaluation data gathered Spring tools developed/refined; evaluation data gathered Summer tools developed/ refined; evaluation data gathered Data synthesized; evaluation report generated	31 Dec 19 31 May 20 31 Jul 20 31 Aug 20
7 Grover	Establish guar trial and showcase guar as potential crop in NM	Host field day Collect data; results synthesized Generate peer-reviewed Extension publication	31 Aug 20 31 Aug 20 31 Aug 20
8 Grover	Guar demonstration	Identify farm willing to host a demonstration field trial Collect data; results synthesized	31 Aug 20 31 Aug 20

9 Gutierr	Develop extension programs and reports for guar/guayule demonstrations	Summarize and validate guayule and guar demonstration farms' data Develop producer summary and presentations for agronomic, climatic, input/output, field emissions, and plant growth data Generate 3 extension bulletins	31 Aug 20 31 Aug 20 1 Feb 20
10 Idowu	Travel to conferences	Present SBAR info/materials at 4-5 grower commodity conferences	31 Aug 20
11 Idowu	Establish guayule and guar trials in Las Cruces, Los Lunas, Clovis, and Tucumcari, NM	Showcase trial experiments at field days Gather data/synthesize results (toward generating an Extension bulletin) Generate first year trial summary (published on SBAR website)	31 Aug 20 31 Aug 20 31 Aug 20
12 Idowu	Establish on-farm demonstration trials	Identify locations for 3 on-farm guar trials Plant guar on-farm trials Identify locations for 2 on-farm guayule trials Plant guayule on-farm trials Collect and summarize planting data for on-farm trials Schedule/Host on-farm walking tour for guar and guayule on-farm demonstration sites	31 Aug 20 31 Aug 20 31 Aug 20 31 Aug 20 31 Aug 20 31 Aug 20
13 Idowu	Host guar-focused conference for producers and ag professionals	Present research results and information on guar Showcase on-farm and on-station trials	31 Mar 20 31 Mar 20
14 Idowu	Newsletters to inform stakeholders	Produce 3 newsletters to highlight SBAR project Distribute fall newsletter Distribute spring newsletter Distribute summer newsletter	31 Aug 20 31 Dec 19 30 Apr 20 31 Aug 20
15 Idowu	Design/schedule/implement E&O evaluation	Fall evaluation data gathered Spring evaluation data gathered	31 Dec 19 31 May 20

		Summer eval data gathered Eval info synthesized; report generated	31 Jul 20 31 Aug 20
16 Teeg	Generate an interactive farm-level economic and financial model (guar and guayule)	Validate and revise BENCO Model for use in Extension/Outreach meetings	31 Aug 20
17 Teeg	Co-develop informational tools for driving profitability/feasibility of crop adoption in AZ & NM	Extension bulletins submitted for review Enterprise budget and BENCO Model available online	31 Aug 20 31 Aug 20
18 Teeg	Participate in Extension meetings; disseminate economic info for guar and guayule	Provide 2 presentations to growers in NM Provide 2 presentations to growers in AZ	31 Aug 20 31 Aug 20

Guar Photographs and Videos:
COVID-19 restrictions in the spring affected photography and video project. We have developed good protocol for developing time-lapse videos and developed a few preliminary time-lapse videos of promise. However, we could not develop videos with temperature specific (treatments of interest) germination process. We are also trying to develop root growth time lapse with a paper scanner method. Initial run seems very impressive. We have to wait for the next graduate student to develop final versions of the products.

Guar Agronomy Research:
Nitrogen and Phosphorous response study was planted and fertilized at Clovis. Due to COVID travel restrictions Dr. Idowu's students could not travel to Clovis. By pooling local resources, we could establish this trial.

Guar Critical Stage Irrigation Study:
2020 Deficit irrigation management trial was planted on time and it is looking very good. Due to COVID-19 restrictions, we may not have many visitors to the trial this year. However, with this year's data, we will be able to summarize results in an extension article for farmers.

Produce Guayule Newsletter Articles:
Nothing new to report.

Develop Outreach Documents for Guayule:
Nothing new to report.

Design and Implement Evaluation Tools:
Grower-Focused Extension – Activities for the grower-focused extension group slowed down considerably due to the COVID pandemic. The cancellation of outreach opportunities and conferences made it more difficult to reach growers and other potentially interested professionals through usual channels. Additionally, some research was halted at least for a short time and in NM there was concern that permissions wouldn't be granted to plant the crops

that would be needed if they were to host demonstration plots and outreach events in the fall. Luckily, the crops made it in the ground and the NM team is hopeful that they will grow successfully and that some outdoor demonstration events will be possible in NM in late summer/early fall, if the cases of the virus stay low in NM.

The extension team was successful in getting another newsletter together and finalized. Distribution is happening widely through the project website, through extension list serves in AZ and NM and via other project staff distribution channels. A task for Q3 is to try to determine the reach of the newsletter.

Extension staff continue to indicate that having the economic model in place will be a key tool for giving growers the information they will need to solidifying their interest in guar and/or guayule. Indicators from surveys given to attendees at the alternative crops conference in NM in March indicate that 27/28 of those completing the surveys improved their understanding of guar as a low input alternative crop (average score of 1.5 before to 3.0 after with 1 being poor and 3 being good.) Similarly, 27/28 indicated that their understanding of guar contracting, processing and marketing had improved (average score of 1.25 before and 2.7 after.)

The Bridgestone tour that had been planned for May in AZ was cancelled and given the current COVID conditions, it is not anticipated that it will be rescheduled in the near future but during Q3 tasks include regular check-ins with the AZ and NM extension teams both to better capture their outward reach with information about the crops and potential bioeconomy and to encourage closer coordination with the education and youth development efforts so that efforts are focused on communities that have the greatest potential to participate in/benefit from the bioeconomy.

Youth Development Extension – Youth development efforts for the project made strides in AZ despite COVID. Some SBAR activities were incorporated into virtual 4-H camps offered by UA. In Q3, evaluation will try to capture information gleaned from that camp by conducting interviews with staff. Plans are in place, and some additional leveraging funding was secured through a Haury grant, to extend SBAR outreach into counties via extension agents as well as through high school STEM ambassadors. Q3 evaluation activities will focus on the processes and outcomes for both efforts.

In NM, Laura ‘s work directly with groups had to stop because of COVID so she too focused on activity development. Evaluation activities included initial review and feedback of curriculum as it is being developed. Iterative versions of each activity will be reviewed as well as all new materials developed to be co-branded with FFA and/or 4-H. For Q3, I will focus some effort on evaluating the ways that the education, extension and youth development efforts are overlapping or building on each other in certain communities, or if they are happening largely in isolation, how to create more coordination to achieve greater collective impact.

Showcase Guar as Potential Crop in New Mexico:
Nothing new to report.

Guar Demonstration:
Due to the ongoing pandemic, it was agreed among the SBAR grower focus extension group that it would be best to wait for the farmer field demonstration until next growing season after the conditions get better.

Develop Extension Programs and Reports for Guar/Guayule Demonstrations:
The enterprise budgets dealing with costs and returns and narrative detailing the agronomic and cultural practices in the production of guar and guayule have been developed in draft form and are under the peer review among SBAR teams. Also, sensitivity analysis associated with net returns of guar and guayule production has been designed with varying costs, yields, and price per pound of dry matters from our key assumption.

A preliminary study on the farm-level impact analysis of guar is progressing using the input-output model. Preliminary results on various case studies related to potential guar production in the three states (AZ, NM, CO) are assessed using IMPLAN.

Travel to Conferences:
We were also unable to conduct any tabling event during this quarter at stakeholder meetings, since all the planned extension meetings in NM were canceled due to COVID-19 pandemic. However, we were able to meet our Year 3 goal of presenting SBAR informational materials at 4-5 grower commodity conferences earlier in the year before the COVID-19 pandemic lockdown (please, see the 2020 Q1 report).

Establish Guayule and Guar Trials in New Mexico:
During this quarter, we planted guar on-station, nitrogen and phosphorus (N & P) demonstration trials in New Mexico at four NMSU Agricultural Science Centers, in Las Cruces, Clovis, Los Lunas and Tucumcari. As of the time of report preparation, the guar trials in Las Cruces, Los Lunas and Clovis are doing well. The guar in Tucumcari is facing some establishment/weed challenges. The results of guar 2019 N & P on-station demonstration trials were compiled, presented to SBAR advisory group and prepared for the SBAR Extension and Outreach Newsletter. The results of guar N & P multilocational trials were also shared with the SBAR Sustainability Team. The guayule cold tolerance study, in collaboration with Bridgestone was expanded in Las Cruces. This cold-tolerance trial will serve as a demonstration site for future field days in Las Cruces, NM. We were unable to establish guar/guayule trials at farmers' fields as intended, due to COVID-19 pandemic.

Photo 7. *Guayule transplants at the Leyendecker Plant Science Center, Las Cruces, New Mexico.*

Establish On-Farm Demonstration Trials:
Nothing new to report.

Host Guar-Focused Conference for Producers and Ag Professionals:
Nothing new to report.

Newsletter to Inform Stakeholders:
During this quarter, the materials for SBAR Extension and Outreach newsletter were collated and will be released in Q3.

Design and Implement Extension & Outreach Evaluation:
Nothing new to report.

Interactive Farm-Level Economic and Financial Model (Guar and Guayule):
Continue to add and update relevant extension model scenarios and data.
Developing the plan for integration of whole-farm adoption tool and collect information during the 4 planned grower presentations.

Informational Tools for Driving Profitability/Feasibility of Crop Adoption in AZ & NM:
Continue to work with AZ and NM Extension team, with the inclusion of new crop options with the current baseline for whole farm analysis to be used in the presentations during the extension/outreach activities. Future of this task depends on COVID-19 restrictions and preferred delivery methods.

Dissemination of Guayule and Guar Economic Information through Extension Meetings:
Working with the extension team to start setting dates for inclusion in extension workshop using the whole farm and budgeting tools. Was not able to schedule participation in any of the extension activities this past quarter but will be able to provide some base information this spring. Future of this task depends on COVID-19 restrictions and available programming efforts. However, we are exploring online options and are now looking into the fall for delivery.

Objective 2. Hold workshops throughout the region on sustainable practices to expand crop production to new rural regions and Native Nation lands.

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Arrange guar field day/field walk at Agricultural Science Centers, NM	Present guar crop information to ~100 producers in the region	31 Aug 20
2 Angadi	Educate local growers	Establish guar demonstration on a local farmer's field	15 Jul 20
1 Evan	Hold workshops and present information to growers in Arizona	Host two presentations on guayule agronomic production and irrigation at regional extension events	31 Aug 20
		Present guayule production to Native American farming communities	31 Aug 20
		Collect needs assessment information directly from Native American farming communities	31 Aug 20

2 Grover	Hold workshops and present information to growers	Host 2 presentations on guar agronomic production as an interim step to bulletin Present SBAR project information and materials	31 Aug 20 31 Aug 20

Educate Local Producers about Guar:
We were extremely lucky to organize the Alternative Crops Conference just before COVID restrictions started. A few farmers showed interest in growing guar crop this year. However, we will not be allowed to organize our annual field day due to pandemic. Dr. Catie Brewer has recruited a local teacher for SBAR educational activity and my graduate student Mr. Paramveer Singh was supposed to work in his classroom. But, it is uncertain at this time.

Establish Farm Demonstration Site in New Mexico:
Recruiting one or two famers to conduct a field scale demonstration of guar in 2020 was not successful. Travel restrictions affected our efforts. We will conduct the demonstration next year.

Grower Workshops in Arizona:
Nothing new to report.

Grower Workshops in New Mexico:
Two abstracts were published and presentations delivered related to educational activities at North American Colleges & Teachers of Agriculture (NACTA) Virtual Conference. One abstract was published and oral presentation delivered on guar at Western Crop Science Society of America 2020 Virtual Conference. Two abstracts on guar work were submitted for 2020 ASA-CSSA-SSSA Annual meeting to be held in November 2020.

A presentation on Guar production and SBAR project was delivered to undergraduate students of *Introductory Plant Sciences course (AGRO/HORT 100G)*.

Information on guar production aspects was provided to a potential grower in Mexico who was my advisee and an alumnus of NMSU Agronomy program. They are considering growing guar at their farm in Sonora desert, Mexico.

Seventeen students were trained in guar research and extension activities through the ongoing SBAR projects.

Three students were also taught *Special Problems/Special Topics*, *AGRO 449/ AGRO 500* where the students participated in hands-on research work in the SBAR guar project and summarized their learning experience through the SBAR project and how they may potentially consider growing guar at their family farm in eastern New Mexico.

In addition, four students were trained as teaching assistants in delivering instruction related to principles of growth and development of plants including guar. One of the students was also taught *Supervised University Teaching Experience, AGRO 697*

A news release was published in local newspaper and NMSU news system about educational activities focusing on experiential learning activities including about guar incorporated in my crop production course at NMSU. Here are links to the two sources:

A new Masters' student (Ms. Stephanie Torres) was recruited in the SBAR guar program from June 1st, 2020.

Participated in 2020 Virtual NACTA conference and served on International Education Committee (renamed as Global Engagement Committee).

Objective 3. Involve youth in internships, 4-H projects, and STEM summer camps.

Task #	Description of Task	Deliverable	Target Completion Date
1 Gutierr	Develop/improve SBAR 4-H Camp curriculum	Adapt camp curriculum for use in NM (train-the-trainer and FFA STEM curriculum)	31 May 20
2 Gutierr	School enrichment and 4H Camp/FFA activities	Plan/Host 6 SBAR Day camps targeting Hispanic and Native youth Plan/Host 15 SBAR school enrichment events Host a train-the-trainer camp for 4H Agents and teachers FFA Science Fair: Promote SBAR curriculum use	31 Aug 20 31 Aug 20 31 Aug 20 30 Jun 20
3 Morris	Adapt existing curriculum for 4H program	Two existing 4H curricula adapted for SBAR topics (bioeconomy)	1 Jun 20
4 Morris	Develop county level STEM Ambassador Program (SBAR-related)	Host focus group meeting with STEM Camp Counselors in June Ambassador guidebook for county implementation	31 Aug 20 31 Aug 20
5 Morris	Design STEM volunteer training program; recruit volunteers	Recruit 5 STEM certified volunteers Host 3 STEM volunteer trainings	30 Apr 20 30 Apr 20
6 Morris	Develop STEM internship program plan, recruitment plan, evaluation plan	Completed internship program plan, recruitment plan, and evaluation plan	30 Sep 20
7 Rock	Develop SBAR internal factsheets on *Project Puente*	Generate *Project Puente* resource document(s) for SBAR faculty	28 Feb 20

8 Rock	Recruit students for summer *Project Puente* internships	Update application materials to highlight on-going SBAR research opportunities Recruit 6 students for Yr3 cohort of *Project Puente* interns	1 May 20 1 May 20
9 Rock	Recruit faculty mentors for summer *Project Puente* internships	Recruit 5 faculty mentors for Yr3 cohort of *Project Puente* interns	1 May 20
10 Rock	*Project Puente* student project development and deployment	Work with SBAR faculty to identify appropriate internship projects (research and extension) Facilitate SBAR internship projects; final poster presentations highlighting student work	26 Jul 20 31 Aug 20
11 Rock	*Project Puente* case study video	Design and develop short video highlighting student/mentor experiences for future training needs	31 Aug 20

Adapt SBAR Curriculum for 4-H and FFA Camps:
Nothing new to report.

SBAR 4-H Day Camps or Mini-Camps:
Nothing new to report.

Adapt Existing Curriculum for 4H Program:
We've selected three curriculum plans: Arid Lands, Agriculture in Arid Lands, and Sustainable Bioeconomy (in development).

Two tribal curriculum extensions are in development for the Arid Lands and the Agriculture in Arid Lands. Each focused on the differences and similarities between native and non-native perspectives on living with and growing on the land.

A new committee of staff and tribal community partners is developing to formalize the adaptation and extension. With committee work on curriculum is to be finalized for sharing during October 3 volunteer training.

Develop County-Level STEM Ambassador Program (SBAR-related):
We cancelled the proposed the STEM counselor focus groups due to virtual programming shift.

Seven youth STEM counselors from Greenlee, Maricopa, Pinal, Santa Cruz, and Yuma counties have gone through skills training and leadership experience during two virtual camps. These youth are being recruited for the county STEM ambassador program. A new committee of staff is in development to plan the county STEM ambassador training on October 10 and determine

final details for program implementation. In addition to staff, this committee will also include our newly inducted State STEM ambassador youth.

Design STEM Volunteer Training Program; Recruit Volunteers:
Four volunteers one each from Santa Cruz County, Pinal County, San Carlos Apache Tribe, and Hopi Tribe participated in skills training and helped lead the AZ 4-H Summit STEM programming and are finishing training for the AR Floating Farm virtual camp now. These adults and others will participate in a volunteer program held on October 3, focused on the SBAR curriculum guidance and supervision of county-level STEM ambassadors.

Develop STEM Internship Program, Recruitment, and Evaluation Plans:
During the AZ 4-H Summit we invited career presentations from the following partners: Arizona Farm Bureau Federation, Dairy Council of Arizona, Bayer Crop Science, Reata Equine, Boehringer-Ingleheim animal health. All of these partners stressed the importance of science skills and innovation in agriculture. We are currently scheduling conversations with each to determine interest in being a host for interns in Summer 2021.

Internal Factsheets on *Project Puente* Internships:
As stated in the quarter 1 report of 2020, during the last two reporting periods the extension team has continued to work to recruit additional SBAR faculty to participate in *Project Puente* for Summer of 2020. As part of our 2020 goals was to develop new resource documents for SBAR faculty on expectations of mentors, expectations of students, timelines, reporting structure, among other topics. We will also create a short PowerPoint presentation directed at recruitment of faculty to participate in the program as well as to be used as an advertisement of the program to the broader campus community. Our initial goal was to increase participation to a total 6 student interns and associated SBAR faculty to participate in the project in year three. Additionally, at the culmination of year three, the extension team planned to create a short case study video to highlight the success of the program for broad dissemination.

Nothing new to report at this time.

Project Puente Internship Recruitment:
Activities have been halted due to COVID-19.

Project Puente Student Project Development and Deployment:
Activities have been halted due to COVID-19.

EDUCATION

Project Coordination: Dr. Sara Chavarria (University of Arizona) serves as the lead for the Education Team, which meets once monthly to cover broader topics related to specific Education objectives and tasks. Smaller working groups meet as-needed for specific action items (such as planning and coordinating the weekly SBAR Fellow Seminar). The Education Team also meets monthly with the Extension & Outreach Team to ensure that selected curriculum and activities is integrated for associated workshops and camps.

Issues/Risks:
Brewer: The shift to remote learning and cancellation of all in-person activities due to COVID-19 greatly limited the time, energy and availability of teachers and fellows to further test or develop SBAR lesson plans during the school year. Uncertainty about the coming school year was also expected to severely limit the ability of teachers to commit to participate in the planned summer SBAR virtual PD. Therefore, that workshop was cancelled. Instead, fellows, teachers and staff focused on finishing lesson plans and deploying them to the SBAR website. The previously created flyer will be used to recruit five NM teachers in July to participate remotely in 2020-2021, supported by Usrey.

One concern about remote delivery of lesson plans was the need for handouts/instructions to be available in Spanish to better enable engagement at home. To address this, Rosalez will work in Q3 on translations for materials as lesson plans are completed.

Chavarria: Before school closure, Knox and Anderson observed two pairs of SBAR Teachers/Fellows. With schools closing, it has not been possible to do classroom observations. With Arizona's COVID infection rate currently one of the highest in the world, it is unlikely that we will be able to visit schools any time soon.

> *Our COVID Pivot:* Contact between the Education team and SBAR Teachers/Fellows via digital means has been more active than ever. There have been weekly contacts between the Education team and teachers/fellows and the development of products has been a good tool to work closely with the team and provide feedback.

Before COVID-19, meetings were held with Nick Morris to use the 4H network to recruit 4H leaders and teachers for the Summer PD. These discussions with Nick have continued throughout the summer as the Education team strategized how to best utilize the 4H Network. The SBAR Education team met with SBAR teachers and other educators throughout the state to learn about their fatigue with Zoom trainings and needs for the coming year. Based on these discussions, it was decided to not hold a traditional PD but to use the summer to focus on the development of education products and digital resources that teachers can use throughout the year.

> *Our COVID pivot:* Teacher recruitment for SBAR involvement has moved from April 2020 to August 2020. Recruitment and orientation to SBAR Educator Partnership will be accomplished through listserves, existing teacher networks, 4-H connections, and other word of mouth strategies. Two SBAR orientation storymaps have been produced and will be used to orient interested educators in continuing their involvement with SBAR. There will be two levels of involvement for Educators, ongoing PD and SBAR resources through monthly digitally delivered synchronous SBAR Education Webinars that will

include presentations by fellows, guest scientists, and staff and access to and demonstrations of SBAR lessons and resources. The second level will include more intensive support by fellows and the availability of mini-grants to support supplies and materials for unit length SBAR lesson implementation. The level two applications for supplies and materials funding will begin in October 2020.

Fields: There have continued to be changes to nearly all planned EEO activities over the past quarter as a result of the COVID pandemic. I have been able to shift my focus to different aspects of the evaluation, including conducting a number of interviews with teachers, fellows and staff as well as reviewing curricular artifacts and working collaboratively with teams as they re-evaluate their plans for the coming months and therefore their evaluation needs change. The final evaluation product for this year may look slightly different than originally intended due to the lack of 'participant data' (i.e. from summer campers or newly recruited teachers) but rather focused on a more in-depth understanding of the most and least valuable aspects of the activities to date.

Objective 1. Train teams of students and teachers with focus on rural and under-represented groups.

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Supervise/Assist NM SBAR Fellows and Teacher Mentors through 2019-2020 school year	Design/deliver after school program for middle school Design/vet STEM activities	31 May 20 31 May 20
2 Brewer	Recruit and train SBAR Fellows and Teachers for 2020-2021 school year	Identify 4 new NM SBAR Fellows and any replacements, as necessary Identify 4 new NM SBAR Middle school teachers	31 Jul 20 31 Jul 20
3 Chav	Plan/Design/Coordinate Fall 2019 and Spring 2020 SBAR Fellow seminar	Plan Fall 2019 seminar content Plan Spring 2020 seminar content Generate education products on SBAR Fellow activities (digital publications)	31 Aug 19 31 Dec 19 31 Jul 20
4 Chav	Visit classrooms for observations (delivery of SBAR content)	Implement Fall teacher observation Implement Fall SBAR Fellow observation Implement Spring teacher observation Implement Spring SBAR Fellow observation	30 Nov 19 30 Nov 19 30 Apr 20 30 Apr 20

5 Chav	Recruit for summer Teacher Professional Development	Plan/develop itinerary for summer PD session Recruit 10+ teachers	31 Jan 20 30 Apr 20
6 Fields	Design/Schedule classroom evaluation tools, protocols and metrics for all Education activities	Fall tools developed/refined; evaluation data gathered Spring tools developed/refined; evaluation data gathered Summer tools developed/ refined; evaluation data gathered Data synthesized; evaluation report generated	31 Dec 19 31 May 20 31 Jul 20 31 Aug 20

Assist NM SBAR Fellows and Teacher Mentors (2019-2020):
Fellows supported their respective teachers (Mikesell, Bradley, and Strand) as best as they could for the remainder of the spring semester. Pruitt and Usrey worked on creation of videos using the purchased GoPro. Bradley was recruited as an expert teacher for summer to complete and refine lesson plans, including resources for teachers delivering content in hybrid formats.

Usrey prepared and had accepted an abstract for the Chemical Engineering Education poster session at the AICHE Annual meeting, currently set for San Francisco in November. That poster will describe the *Guardians of the Biosphere* afterschool program and SBAR lesson/activity development.

Recruit and Train SBAR Fellows and Teachers (2020-2021):
In May, the education team restructured the plan for the NM teachers and fellows in light of the COVID-19 pandemic and the shift to remote learning. The deliverable on Task #2 was changed to 3 NM fellows, 2 in-person and 5 remote NM middle school teachers identified and trained, which has now been met except for recruitment of NM teacher participating remotely. Alan Daugherty from Melrose School District was recruited to work with Paramveer in 2020-2021 to enable in-person work within a rural NM school close to the guar-growing region. Pruitt will continue to work in-person with Strand within LCPS.

SBAR Fellow Seminar (Fall 2019 / Spring 2020):
SBAR fellows met with Anderson and Knox twice weekly on their development of digital products. Karina Martinez joined this summer as a new SBAR fellow and the summer meetings were also used to orientate her to the program.

Fellows were assigned with reviewing SBAR lessons to identify characteristics such as how original the lesson is compared to other lessons, additional resources to be added to the lesson, and ways to incorporate cultural relevance and connections to arid lands. The fellows also took part in readings/discussions, refined an SBAR activity or lesson plan, and developed questions teachers can ask their students while they watch SBAR expert interviews videos. The purpose of developing questions teachers can have their students write about/discuss extends the

usefulness of the videos and allows the fellows to introduce their work and the backgrounds of the interviewees.

The summer assignments and working sessions focused on how to develop unique products/resources and how we can make them relevant and useful for educators. Anderson and Knox met individually with fellows to provide feedback on educational products.

We also met with Nick Morris to develop how the SBAR fellows could participate/present in upcoming 4H activities. The development of presentations for 4H and review of each other's products have helped with cross-pollination and identifying how their educational products are connected. The readings and discussions on cultural relevance enriched the products that were developed. For example, Arisbeth Ibarra has begun developing a bilingual bingo game called La Loteria—abiotic and biotic factors (Figure 48). This is a unique approach that brings together science, culture, and language learning into a game that explores SBAR topics in an innovative way.

Through ongoing support and regular meetings, the fellows are demonstrating growth in their ability to create lesson plans and educational resources. Huitlzilin Ortiz has developed a database connecting AZ and NM science standards to SBAR themes for use in new educator orientation/training (fall).

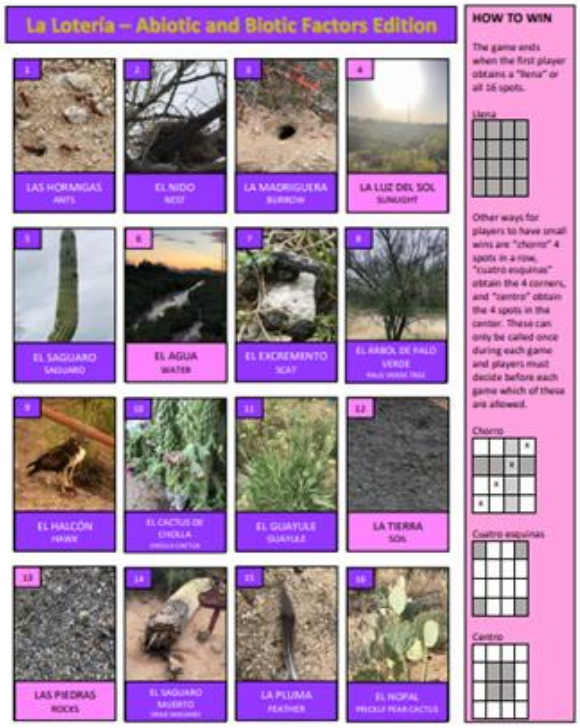

Figure 48. *La Loteria card game developed by SBAR Fellow, Arisbeth Ibarra Nieblas.*

Classroom Observations (Delivery of SBAR Content):
Due to the COVID-19 pandemic, this activity is delayed. Nothing new to report.

Teacher Recruitment for Summer Professional Development:
Nothing new to report.

Design and Implement Classroom Evaluation Tools:
During the Q2 of 2020, the primary tasks related to the evaluation of the education components of the SBAR project were initially focused on developing evaluation tools for an online professional development experience. Early work during the quarter included research towards the evaluation of the planned virtual summer professional development the recruitment of teachers for participation.

Due to the realization that teachers were facing remote teaching/learning burnout, and knowing the burden on teachers to develop additional online learning resources for the anticipated continuation of remote learning in the fall, the plan to recruit for and offer a summer PD experiences was cancelled.

At that point, my efforts transitioned to the planning and conduct of focus group and individual interviews with teachers and fellows across AZ and NM. These interviews were intended to gain insight about a number of items, including for teachers: if and how they implemented SBAR lesson plans remotely; their overall experience with their graduate fellow; what types of resources are most valuable moving forward, how they thought the education team would be most successful at recruiting teachers for virtual trainings and to use the materials.

Teachers overwhelmingly indicated a high satisfaction with both the program and their graduate student fellow. They all seemed to agree that having a fellow who is a science or engineering graduate student and can interact with both the teacher and their students through that framework is more valuable than having a fellow paired with them who is an education graduate student. Teachers who work primarily with Native American students indicated that there was added value in exposing their students additionally to people from other cultures. Those teachers also indicated however that they would have liked to see more coordination with the extension agents and extension activities in their community to reinforce the 'real-world' elements of the SBAR project.

Teachers from NM indicated a similar desire to be more closely connected to extension agents but more for the purpose of influencing local water use decisions. They felt that more messaging about the benefits of growing guar could have made a difference in local decision makers choice to provide more water towards growing pecans rather than investing in guar. When asked about the types of learning resources that would be most valuable, they indicated that the lesson plans accompanied by additional resources, particularly videos from researchers, growers and other SBAR project team members would be particularly valuable for remote learning.

They also mentioned that the recently released science standards place a heavy emphasis on working with data, and said that if some SBAR activities could be developed that explore ways to use data sets that would be valuable.

When I asked how (new) teachers might best connect with SBAR materials, they indicated that some organization around standards would be best as they almost all said that they search for classroom activities by the standards. When asked about the alignment of the activities with their required subject areas, and therefore ease of incorporating them into their overall lesson plans, they each described ways that they adapted. For some, they found the particular SBAR activities that aligned with the specific science standards/content areas they were teaching during that period and integrated them into the overall curriculum. This approach was more difficult for some subject areas, like astronomy, but worked very well for a number of subjects including earth/environmental science and chemistry.

For others, they dedicated each Friday for 'SBAR day' and spent the day doing SBAR activities so they were able to present them in a more sequenced way. Both approaches seemed to gain

positive reactions from the students, whose favorite parts were the hands-on activities and also interacting with the graduate fellows. When asked if they were able to incorporate career information, it tended to be primarily about becoming a scientist and the pathways including college, and also a little bit about farming.

The fellows also indicated a high degree of satisfaction with their participation in the project. They felt that they had learned valuable professional skills through working with their teacher partner, including lesson plan development and implementation and classroom management. They indicated a high degree of satisfaction particularly from the interactions directly with students.

They each indicated a slightly different way of collaborating with their teacher partners – some worked more independently and exchanged materials and feedback via email, while others spent more time in the classrooms working directly with students. This was for a number of reasons including schedule alignment (or lack thereof) or distance to the school, as was in the case of the school near Sells. While some teachers' time with SBAR was coming to an end, they indicated that they would continue to utilize the materials.

At least one teacher is continuing to work with the project over the summer to further develop the curricular materials and associated videos. Tasks in Q3 will include reviewing the curricular materials developed and continuing to prepare for the next steps as the education team decides when they will be prepared to schedule virtual professional development activities for additional teachers.

An ongoing task related to the education efforts was to continue to review documents/project artifacts such as teacher and fellow lesson plans as they are in development to monitor progress towards curriculum deliverables;

Objective 2. Develop and disseminate agricultural bioenergy and bioproduct K-12 modules.

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Develop/Offer train-the-trainer biofuels education program for 4-H agents/volunteers and teachers/fellows	Develop/Host 3-day summer train-the-trainer program at NMSU Recruit 4-H youth and GK-12 participants	31 Jul 20 31 Jul 20
2 Chav	Edit Cohort 1 lessons and materials for online publication	Edit lessons Submit final lessons/activities for SBAR website and online publication	31 Oct 19 31 Dec 19
3 Chav	Support lesson plan design by teacher-Fellow partnerships	Fall lesson plans from each Fellow developed	30 Nov 19

		Spring lesson plans from each Fellow developed	30 Apr 20
		Advice and support NM teach as requested/needed	31 May 20
		Draft lesson plans from Cohort 2 teachers	31 Jul 20
		Cohort 2 summer support on lesson redesign for publication	31 Jul 20

Design and Implement Train-the-Trainer Education Program for 4-H Youth Development:
Due to COVID-19, the summer PD was cancelled. The advertisement flyer generated will be tweaked for reuse in the future.

Cohort #1 Lessons and Materials:
Nothing new to report.

Support Lesson Plan Design by Teacher-Fellow Partnerships:
The SBAR Spring Seminar ended with NM fellows joining the AZ class to share their work and discuss future plans with their teachers. Catie Brewer also attended the end of the seminar and consulted with the UA Education team to hire SBAR teacher Cathy Bradley to work on NM lesson plans. Knox met with Cathy Bradley two times to guide her work. Knox is currently reviewing her completed lessons.

Chavarria, Knox, and Anderson met with the Arizona teachers to discuss the challenges facing them in their schools and future plans for the Fall school year. There are many unknowns for the teachers with the school start being pushed back to August 17th due to COVID-19 and classes beginning digitally for many schools. The education team brainstormed with teachers about digital tools that could be used for SBAR products. Chavarria, Knox, and Anderson each worked with teachers throughout the summer to draft lesson plans and strategize how to bring SBAR content to classes that are not meeting in person.

SBAR Education products and resources:
Overview Videos: https://sbar.arizona.edu/education/educational-resources/videos
Revised Lessons: https://sbar.arizona.edu/education/educational-resources/lesson-plans
(Other designed materials are not yet public.)

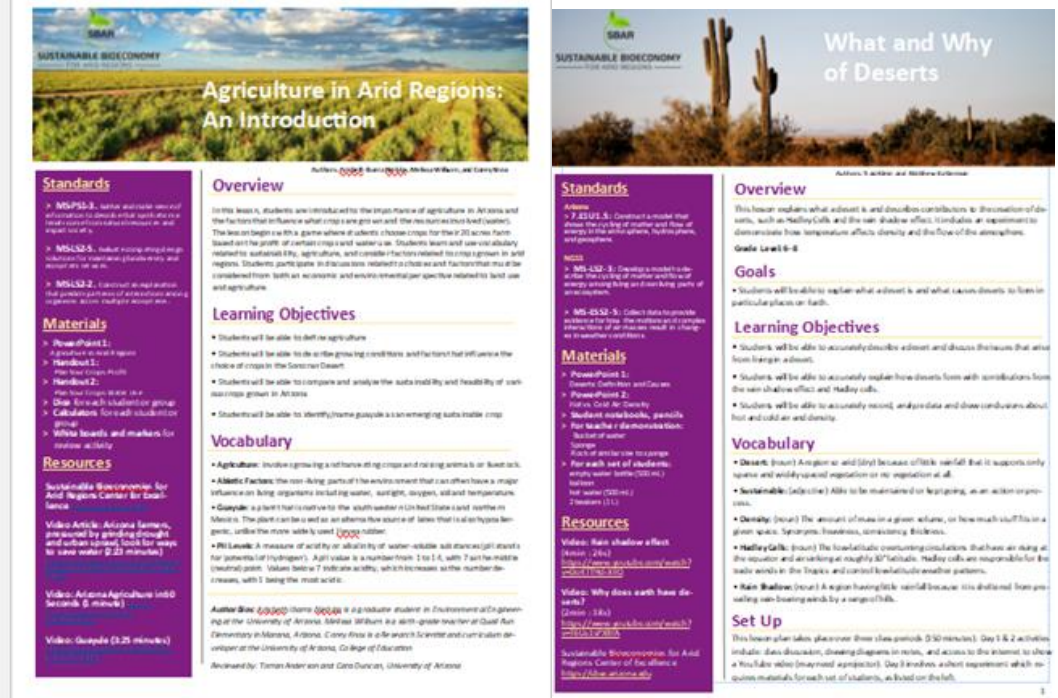

Figure 49. *Screenshot examples of a lesson plan created by SBAR Fellow and SBAR Teacher teams.*

Objective 3. Develop a biofuel certificate program at the university level.

Task #	Description of Task	Deliverable	Target Completion Date
1 Molnar	Develop MS and/or PhD education opportunities within the University of Arizona around the theme of "Sustainable Bioeconomy"	At least 2 tracks (study concentration areas) within UA GIDPs	31 Dec 19

Development of Education Opportunities:
This task is complete; nothing new to report.

AWARDS

2020

Ossanna, L. *National Science Foundation Graduate Research Fellowship.* Awarded 3 years of funding to complete a PhD.

2019

Bayat, H.; Hoare, D.; Moreno, L.; Singh, J.; Steichen, S.; Summers, H.; Wright, A. *SBAR Interdisciplinary Face-Off – Silver Lightning Award for Best Overall Design*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

Bayat, H.; Hoare, D.; Moreno, L.; Singh, J.; Steichen, S.; Summers, H.; Wright, A. *SBAR Interdisciplinary Face-Off – Smooth Moves Award for Most Creative Concept*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

Brown, K.; Dehghanizadeh, M.; Lohr, P.; Singh, P.; Soto, A.; Zuniga-Vasquez, D. *SBAR Interdisciplinary Face-Off – Ninja Visionary Award for Best Overall Concept*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

Katterman, M.; Ossanna, L.; Pruitt, D.; Soliz, N.; Sproul, E. *SBAR Interdisciplinary Face-Off – Energy Zone Award for Overall Audience Favorite*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

PRODUCTS GENERATED.
September 2017 – June 2020

PUBLICATIONS, CONFERENCE PAPERS AND PRESENTATIONS

Items appearing in blue font are new in this quarter.

Publications

1. **Abdell-Haleem H.; Luo Z.; Ray, D. 2019.** Chapter 6. Genetic Improvement of Guayule (*Parthenium argentatum* A. Gray): An Alternative Rubber Crop. *In.* J. Al-Khayri (ed.). Advances in Plant Breeding Strategies: Industrial and Food Crops. Springer Nature Switzerland AG (Invited Book Chapter). p.151-178.
2. **Chen, F.; Bayat, H.; Jena, U.; Brewer, C.E. 2020.** Impact of feedstock composition on pyrolysis of low-cost, protein and lignin-rich biomass: a review. *Journal of Analytical & Applied Pyrolysis*, 147, 104780, DOI: 10.1016/j.jaap.2020.104780.
3. **Chen, F.; Dehghanizadeh, M.; Audu, M.A.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2020.** Characterization and evaluation of guayule processing residues as potential feedstock for biofuel and chemical production. *Industrial Crops and Products*, 150, 112311. DOI: 10.1016/j.indcrop.2020.112311.
4. **Cheng, F.; Jarvis, J.M.; Yu, J.; Jena, U.; Nirmalakhandan, N.; Schaub, T.M.; Brewer, C.E. 2019.** Bio-crude oil from hydrothermal liquefaction of wastewater microalgae in a pilot-scale continuous flow reactor, *Bioresource Technology*, 294, 122184, DOI: 10.1016/j.biortech.2019.122184.
5. **Cheng, F.; Le-Doux, T.; Treftz, B.; Miller, J.; Woolf, S.; Yu, J.; Jena, U.; Brewer, C.E. 2019.** Modification of a pilot-scale continuous flow reactor for hydrothermal liquefaction of wet biomass. *MethodsX*, 6, 2793-2806, DOI: 10.1016/j.mex.2019.11.019.
6. **Cheng, F.; Bayat, H.; Jena, U.; Brewer, C.E. ND.** Impact of feedstock composition on pyrolysis of low-cost, protein-rich lignocellulosic biomass: a review. *Journal of Analytical & Applied Pyrolysis*, revised, under review.
7. **Cheng, F.; Dehghanizadeh, M.; Audu, M.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. ND.** Characterization and evaluation f guayule bagasse and processing residues as potential feedstock for biofuel and chemical production. *Industrial Crop & Products*, in revision.
8. **Dehghanizadeh, M.; Cheng, F.; Jarvis, J.M.; Holguin, F.O. Brewer, C.E. 2020.** Characterization of resin extracted from guayule (*Parthenium argentatum*): a dataset including GC-MS and FT-ICR MS. *Data in Brief*, 105989. https://doi.org/10.1016/j.dib.2020.105989.
9. **Luo, Z.; Thorp, K.R., Abdel-Haleem, H. 2019.** A high-throughput quantification of resin and rubber contents in *Parthenium argentatum* using near-infrared (NIR) spectroscopy. *Plant Methods* 15, 154 (2019) DOI:10.1186/s13007-019-0544-3.
10. **Nelson, A.D. L.; Ponciano, G.; McMahan, C.; Ilut, D.C.; Pugh N.A.; Elshikha, D.E.; Hunsaker, D.J.; Pauli. D. 2019.** Transcriptomic and evolutionary analysis of the mechanisms by which *P. argentatum*, a rubber producing perennial, responds to drought. *BMC Plant Biology*. 19:494. https://bmcplantbiol.biomedcentral.com/articles/10.1186/s12870-019-2106-2

11. **Sproul, E.; Summers, H.M.; Seavert, C.; Robbs, J.; Khanal, S.; Mealing, V.; Landis, A.E.; Fan, N.; Sun, O.; Quinn, J.C. N.D.** Integrated Techno-Economic and Environmental Analysis of Guayule Rubber Production. *Journal of Cleaner Production* [In Press]. Accepted June 2020.
12. **Sun, O.; Fan, N. 2020.** A Review on Optimization Methods for Biomass Supply Chain: Models and Algorithms, Sustainable Issues, Challenges and Opportunities. *Process Integration and Optimization for Sustainability*, published online first, 3/2020. DOI:10.1007/s41660-020-00108-9

Capstone Projects, Theses, and Dissertations

1. **Ledesma, J.*; Ossanna, L; Pacido, D.; El-Shikha, D.E.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M.; Neilson, J.W. 2020.** *Associations between soil rhizosphere bioavailable phosphorus, phosphorus solubilizing microorganisms, and guayule growth stage and rubber production*. Senior Capstone Thesis, University of Arizona, Tucson, Arizona.
2. **Singh, Jagdeep. 2020.** Guar growth and development under pre-irrigation and in-season irrigation management in the Southern High Plains. Master of Science Thesis, New Mexico State University, Las Cruces, New Mexico.

Conference Papers

1. **Audu, M.; Dehghanizadeh, M.; Cheng, F.; Bayat*, H.; Holguin, O.; Jena, U.; Brewer, C.E. 2019.** *Co-Products and Biofuels from Guar and Guayule Processing Residues*. 2019 ASABE Annual International Meeting. Boston, Massachusetts. 8 July. Paper #1900361.
2. **Cruz, V.M.V.; Lynch, A.; Wang, G.S.; Dittmar, S.; Sullivan, T.; Prock, R.; Niaura, W.; Dierig, D.A. 2019.** *Guayule germplasm characterization for variation in ploidy and biomass production.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 36.
3. **Dehghanizadeh, M.*; Cheng, F.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2019.** *High Resolution Mass Spectrometry for Characterization of Resin from Guayule (Parthenium argentatum).* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 39.
4. **Dehghanizadeh, M.*; Brewer, C.E. 2019.** *Guayule resin: chemistry, extraction, and applciations,* 2020 ASABE Annual International Meeting, Virtual. 13-15 July. DOI: 10.13031/aim.202001143.
5. **Dierig, D.A.; Wang, G.S.; El-Shikha, D.E.M.; Sullivan, T.; Dittmar, S.; Cruz, V.M.V. 2019.** *Guayule growth and yield over time at two locations at high and low irrigation treatments.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 31.
6. **Dong, C.; Ponciano, G.; Wang, Y.; Huo, N.; Hunsaker, D.; El-Shikha, D.E.M.; Gu, Y.Q.; McMahan, C. 2019.** *Gene expression of guayule field plants under drought stress: A comparative RNA-Seq study.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 35.

7. **El-Shikha, D.E.M.*; Waller, P.M.; Hunsaker, D.J.; Dierig, D.A.; Wang, G.S.; Cruz, V.M.V.; Thorp, K.R.; Bronson, K.F.; Katterman, M.E. 2019.** *Growth and yield of direct-seeded guayule under SDI and furrow irrigation.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 30.
8. **Khanal, S.; Robbs, J.; Acharya, R.; Gutierrez, P. 2019.** *Import demand and potential for domestic production of guar.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 43.
9. **Maqsood, H.; Waller, P.; El-Shikha, D.E.M.; Hunsaker, D.; Katterman, M.E.; Dierig, D.A.; Wang, G.S.; Ogden, K. 2019.** *Assessment of irrigation requirement for guayule using WINDS model.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 32.
10. **Maqsood, H.; Angadi, S.; El-Shikha, D.E.M.; Waller, P.; Singh, J.; Hunsaker, D.; Barau, B. 2019.** *Evaluating crop water status for guar using WINDS model.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 42.
11. **McCloskey, W.; Wang, G.S. 2019.** *Guayule (Parthenium argentatum A. Gray) seedling tolerance to topically applied carfentrazine-ethyl herbicide.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 34.
12. **Placido, D.F.; Dong, N.; Pham, T.; Huynh, T.; Amer, B.; Baidoo, E.; McMahan, C. 2019.** *Down-regulation of squalene synthase in guayule (Parthenium argentatum).* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 37.
13. **Seavert, C.; Teegerstrom, T.*; Gutierrez, P.; Khanal, S. 2019.** *Whole farm analysis tool for evaluating the adoption of guayule and guar into southwest producers' current operation.* In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 40. Best Oral Presentation Award for the Rubber and Resin Division.
14. **Wang, G.S.; Dierig, D.A.; Ray, D.T. 2019.** *Guayule response to plant population*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 38.

Scholarly Presentations

1. **Angadi, S.V. 2018.** *Sustainable Bio-economy for Arid Regions: Growing Guar.* Extension Field Day. Clovis, New Mexico. 9 August.
2. **Angadi, S.V.*; Begna, S.H.; Singh, S.; Katuwal, K.; Singh, J.; Gowda, P.; Ghimire R. 2018.** *Multiple Approaches to Sustain Ogallala Aquifer in the Southern Great Plains of the United States of America*. Agrosym 2018. Jahorina, Bosnia. 4-7 December.
3. **Angadi, S.V.*; Begna, S.H.; Singh, S.; Katuwal, K.; Singh, P.; Singh, J.; Umesh, M.R. 2019.** *Crop Diversification and Critical Stage-Based Irrigation to Sustain Ogallala*

Aquifer. UCOWR/NIWR Annual Water Resources Conference, Snowbird, Utah. 11-13 June.

4. **Angadi, S.V.*; Begna, S.H.; Umesh, M.R. 2018.** *Crop diversification for sustainable soil and water resources use in semi-arid regions of USA*. XXI Biennial National Symposium of Indian Society of Agronomy, Udaipur, India. 24-26 October.
5. **Angadi, S.V.*; Singh, J.; Begna, S.H. 2019.** *Crop growth stage based deficit irrigation management in guar crop*. Annual Report, Agricultural Science Center at Clovis, New Mexico. 20 February.
6. **Angadi, S.V.; Singh, J.*; Begna, S.H. 2020.** *Crop growth stage-based deficit irrigation management in guar crop*. Annual Report, Agricultural Science Center at Clovis, New Mexico. 29 February.
7. **Audu, M.*; Dehghanizadeh, M.; Cheng F.; Bayat H.; Holguin, O.; Jena U.; Brewer, C.E. 2019.** *Co-Products and Biofuels from Guar and Guayule Processing Residues*. ASABE Annual International Meeting, Boston, Massachusetts, 7-10 July.
8. **Bayat, H.*; Cheng, F.; Jena, U.; Brewer, C.E. 2019.** *Introduction to low-cost protein-rich lignocellulosic biomass for advanced biofuels.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
9. **Brewer, C.E. 2018**. *Pairing biomass residues with conversion technologies*. Advanced Bioeconomy Leadership Conference, Washington, D.C. 28 February.
10. **Brewer, C.E. 2018**. *Polymerization and guar gum bubbles*. Outreach event activity. New Mexico 4-H State Conference. 11 July.
11. **Brewer, C.E. 2018**. *Identifying Co-Products from Guar and Guayule Processing Residues*. 2018 American Institute of Chemical Engineers Annual Meeting. Pittsburgh, Pennsylvania. 30 October.
12. **Brown, K.S. 2020.** *Soil chemistry … and other topics*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 25 March.
13. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray D.T.; Dierig, D.; Maier, R.M. 2018.** *Microbial contributions to soil health: Optimizing guayule (Parthenium argentatum) production in an arid environment*. SWESx Earthday Symposium. Tucson, Arizona. 15 April. [poster]
14. **Brown, K.S.*; Neilson, J.W. 2018.** *Microbial contributions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. April.
15. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray D.T.; Dierig, D.; El-Shikha, D.;Maier, R.M. 2019.** *Microbial contributions to soil health: Optimizing guayule (Parthenium argentatum) production in an arid environment*. SWESx Earthday Symposium. Tucson, Arizona. 27 March. [poster]
16. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray, D.T.; Wang, S.; Dierig, D.; El-Shikha, D.E.M.; Maier, R.M. 2019.** *Soil health and guayule microbial community metrics.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
17. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray, D.T.; Wang, S.; Dierig, D.; El-Shikha, D.E.M.; Maier, R.M. 2020.** *Fungal pathogens and guayule (Parthenium argentatum): Optimizing crop production in an arid environment.* University of Arizona ENViSion Virtual Earth Week Conference, Tucson, Arizona. April.
18. **Cheng, F.*; Audu, M.; Dehghanizadeh, M.; Treftz, B.; Le-Doux, T.; Jena, U.; Brewer, C.E. 2018.** *Characterization and Conversion of Guar and Guayule Bagasse*

as Potential Resources for Biofuels Production. Symposium on Thermal and Catalytic Sciences for Biofuels and Bio-based Products. Auburn, Alabama. 9 October.

19. **Cheng, F.; Le-Doux, T.; Jena, U.; Brewer, C.E.* 2018.** *Characterization and Conversion of Guar Bagasse.* Symposium on Thermal and Catalytic Sciences for Biofuels and Bio-based Products. Auburn, Alabama. 9 October.
20. **Cheng, F. 2018.** *Hydrothermal Liquefaction of Microalgae in Batch and Continuous Flow Reactors.* PhD Dissertation Defense. New Mexico State University, Las Cruces, New Mexico. 24 October.
21. **Cheng, F.*; Rosalez, R.; Dehghanizadeh, M.; Brewer, C.E. 2019.** *Co-Hydrothermal Liquefaction of Guayule Bagasse and Wastewater Treatment Microalgae*. American Institute of Chemical Engineers (AIChE) Annual Meeting, Orlando, Florida. 10-15 November.
22. **Cheng, F.*; Le-Doux, T.; Treftz, B.; Woolf, S.; Guillen, S.; Usrey, J.; Martinez Bejarano, C.; Bayat, H.; Jena, U.; Brewer, C.E. 2018.** *Characterization of Flow and Heat Transfer Parameters in a Continuous Flow Hydrothermal Liquefaction Reactor.* 2018 American Institute of Chemical Engineers Annual Meeting, Pittsburg, Pennsylvania. 1 November.
23. **Cheng, F.*; Rosalez, R.; Dehghanizadeh, M.; Brewer, C.E. 2019.** *Co-Hydrothermal Liquefaction of Guayule Bagasse and Wastewater Treatment Microalgae.* 2019 American Institute of Chemical Engineers Annual Meeting, Orlando, Florida. 10-15 November.
24. **Creegan, E.; Grover, K.*; DuBois, D.; Khan, N. 2020.** *Global climate change mitigation and resiliency: Agriculture Curriculum Collaborations.* North America Colleges and Teachers of Agriculture Virtual Conference, Online. 15-18 June.
25. **Dehghanizadeh, M.*; Cheng, F.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2019.** *High Resolution Mass Spectroscopy for Characterization of Resin from Guayule*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
26. **Deirig, D. 2017.** *Bridgestone's perspective on a domestic source of natural rubber in the desert.* Invited Speaker at the New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico. 13 December.
27. **Dong, C.; Ponciano, G.; Wang, Y.; Huo, N.; Hunsaker, D.; Elshikha, D.; Gu, Y.Q.; McMahan, C. 2019.** *Transcriptome analysis of guayule reveals rubber biosynthesis pathways' response to drought stress*. SBAR Annual Retreat, University of Arizona, Tucson Arizona. 11-13 September. [poster]
28. **El-Shikha, D.E.M. 2018.** *Update – Guayule irrigation experiments at Maricopa Agricultural Center*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 12 September.
29. **El-Shikha, D.E.M.*; Waller, P.M.; Hunsaker, D.J.; Dierig, D.; Wang, S.; Cruz, V.M.V.; Bronson, K.F.; Katterman, M.E. 2019.** *Direct seeded guayule grown in Arizona under furrow and subsurface drip irrigation.* American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting, Boston, Massachusetts. 8 July. [poster]
30. **El-Shikha, D.E.M*.; Waller, P.M.; Hunsaker, D.J.; Dierig, D.; Wang, G.S.; Cruz, V.M.V.; Thorp, K.R.; Katterman, M.E.; Bronson, K.F.; Wall, G. 2019.** *Growing direct-seeded guayule with furrow and subsurface drip irrigation in Arizona.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]

31. **Evancho, B.*; Teetor, V.H.; Willmon, J.; Bennett, M.C.; Montes, M.; Schmaltzel, C.; Ray, D.T. 2018.** *Root structure differentiation between common guayule planting methods.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
32. **Evancho, B. 2018.** *Guayule Fuels the Future*. IES – Energy Talks Seminar, Sky Bar, Tucson, Arizona. 9 October.
33. **Evancho, B. 2019.** *Guayule: How Close Are We?* Marana Winter Field Crops Clinic. Marana, Arizona. 10 January.
34. **Evancho, B. 2019.** *Guayule: How Close Are We?* Casa Grande Winter Field Crops Clinic. Casa Grande, Arizona. 15 January.
35. **Evancho, B. 2019.** *Comparing direct-seeded and transplanted guayule roots*. SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 13 November.
36. **Evancho, B. 2020.** *Growth response of guayule to a gradient of nitrogen fertilizer*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 29 April.
37. **Evancho, B.*; Moreno, L.; Peck, A.; Teetor, V.H., Schmalzel, C.; Ray, D.T. 2019.** *Root structure differentiation between guayule planting methods.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
38. **Fan, N. 2018.** *Review on Optimization Methods for Biomass Supply Chain*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
39. **Fan, N.; Sun, O. 2019.** *GIS-based, two-stage stochastic facility location problem considering planting plan uncertainty*. American Institute of Chemical Engineers (AIChE) Annual Meeting, Orlando, Florida. 11 November.
40. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar (Cyamoposis tetragonoloba L.) under various irrigation regimes in semi-arid region of New Mexico*. 73rd SWCS International Annual Conference, Albuquerque, New Mexico. 29 July – 1 August.
41. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar under various irrigation regimes in semi-arid region of New Mexico*. Annual SBAR Retreat, University of Arizona, Tucson, Arizona. 1-3 August. [poster]
42. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Performance of guar under various irrigation regimes in southern New Mexico*. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.
43. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018**. *Performance of guar under various irrigation regimes in southern New Mexico.* New Mexico Sustainable Agriculture Science Conference, Los Lunas, New Mexico. 12 December.
44. **Garcia, A.*; Grover, K.; Schutte, B.; Stringam, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar under various irrigation regimes*. Proceedings of the 2018 Annual Meeting of the American Society of Agronomy, Crop Science Society of America and the Soil Science Society of America. Baltimore, Maryland. 4-7 November.
45. **Garcia, A.*; Grover, K.; Schutte, B.; Stringam, B.; VanLeeuwen, D. 2019.** *Growth and performance of guar under different irrigation regimes*. NMSU College of Agriculture, Consumer and Environmental Sciences (ACES) Open House. 6 April. [poster]

46. **Gloria, T.*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico*. Annual SBAR Retreat, University of Arizona, Tucson, Arizona. 1-3 August. [poster]
47. **Gloria, T.*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico*. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.
48. **Gloria, T.*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico.* New Mexico Sustainable Agriculture Science Conference, Los Lunas, New Mexico. 12 December.
49. **Gloria, T.*; Flores, M.; Allen, R.; Valenzuela, V.; Ben, G.; Moore, K.; Castillo, P.; Garcia, A.; Grover, K. 2019.** *Evaluating guar as a potential alternative crop in New Mexico.* NMSU College of Agriculture, Consumer and Environmental Sciences (ACES) Open House, Las Cruces, New Mexico. 6 April. [poster]
50. **Godfrey, D.J; Bennett, M.C.*; Willmon, J.; Waltz, Q.; Coronado, G.; Teetor, V.H.; Schmalzel, C.; Ray, D.T. 2018**. *Vegetative propagation of Parthenium argentatum (Guayule).* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster] Won first place for undergraduate posters.
51. **Godfrey, D.*; Willmon, J.; Teetor, V.H.; Schmalzel, C.; Ray, D.T. 2018.** *Vegetative propagation of guayule*. 2018 Annual Conference, American Society for Horticultural Science, Washington D.C. 30 July – 3 August 2018.
52. **Gonzalez, C.; Dierig, D.A.; Cruz, V.M.V.* 2019.** *Pollen studies in guayule: Comparison of staining and sampling procedures and survey of pollen size variation.* 31st Annual Meeting for the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
53. **Gonzalez, C.*; Cruz, V.M.V.; Dierig, D.A. 2019.** *Pollen viability and size variation in guayule germplasm.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
54. **Grover, K. 2017.** *Guar as a potential alternative crop in New Mexico*. Invited Speaker at the New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico. 13 December.
55. **Grover, K. 2018.** *Sustainable agriculture and guar production in New Mexico*. New Mexico State 4-H Conference, Las Cruces, New Mexico. 10 July.
56. **Grover, K. 2018**. *An overview of guar and other research in the Plant and Environmental Sciences Department*. A presentation to student ambassadors of College of Agriculture, Consumer and Environmental Sciences, New Mexico State University, Las Cruces, New Mexico. 8 August.
57. **Grover, K. 2018**. *Guar as an alternative crop in New Mexico.* Extension Field Day, New Mexico State University Agriculture Science Center, Clovis, New Mexico. 9 August.
58. **Grover, K. 2018**. *Guar as an alternative crop in New Mexico.* Extension Field Day, New Mexico State University Agriculture Science Center, Artesia, New Mexico. 23 August.
59. **Grover, K. 2018**. *Guar and Sustainable Crop Production.* An invited presentation to students of *AGRO/HORT 100 Introductory Plant Sciences*. New Mexico State University, Las Cruces, New Mexico. 31 August.

60. **Grover, K. 2018**. *Guar and Sustainable Crop Production.* An invited presentation to students of *AXED 466V: "John Muir: Lessons in Sustainability."* New Mexico State University, Las Cruces, New Mexico. 25 September.
61. **Grover, K. 2019.** *Guar as an alternative rotation crop in the chili production system of New Mexico.* New Mexico Chili Industry and Researcher Meeting, Las Cruces, New Mexico. 5 February.
62. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico.* Climate Change Strategies for a Changing World Workshop, New Mexico State University, Las Cruces, NM. 5 February. [invited speaker]
63. **Grover, K. 2019.** *Do you know what plants are these and what's in them?* Future Farmers of America (FFA), New Mexico Chapter Presentation. Las Cruces, New Mexico. 5 April.
64. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico*. New Mexico Master Gardener's Meeting. Las Cruces, New Mexico. 8 May.
65. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. New Mexico Sustainable Agriculture Field Day. Las Cruces, New Mexico. 26 June.
66. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. SBAR Train-the-Trainer Workshop. Las Cruces, New Mexico. 2 July.
67. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. SBAR Train-the-Trainer Workshop, Las Cruces, New Mexico. 2 July.
68. **Grover, K. 2019.** *Guar research and extension program in New Mexico*. Departmental External Review, Las Cruces, New Mexico. 10 October.
69. **Grover, K. 2020.** *Guar as an alternative crop in southwest USA*. 18th International Congress of Soil Science, Sindh Agriculture University, Tandojam, Pakistan. 11-13 Februrary. [invited speaker]
70. **Grover, K. 2020.** *Guar in changing climate*. Climate Change Strategies for a Changing World, New Mexico State University, Las Cruces, New Mexico. 3 March. [invited speaker]
71. **Grover, K. 2020.** *Guar as a potential alternative crop*. Introductory Plant Sciences course (AGRO/HORT 100G), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
72. **Grover, K. 2020.** *Evaluating performance of guar genotypes*. Special Problems/Special Topics Seminar (AGRO 449/AGRO 500), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
73. **Grover, K. 2020.** *Teaching principles of plant growth and development.* Teaching Assistant Training and Supervised University Teaching Experience (AGRO 697), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
74. **Grover, K. 2020.** Evaluating guar for its adaptability in New Mexico. Research and Education Training Workshop. New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
75. **Grover, K.*; Garcia, A. 2018.** *Evaluating guar as a potential alternative crop in New Mexico*. University Research Council Meeting, New Mexico State University. Las Cruces, New Mexico. 15 February.
76. **Grover, K.*; Garcia, A.; Schutte, B.J.; Stringam, B.; Darapuneni, M.K.; VanLeeuwen, D. 2019.** *Response of guar to various irrigation regimes*. ASA-CSSA-SSSA International Annual Meetings, San Antonio, Texas. 12 November.

77. **Grover, K.*; Garcia, A.; Schutte, B.J.; Stringam, B.; Darapuneni, M.K.; VanLeeuwen, D; Flynn, R.P. 2020.** *Growth and performance of guar under various moisture stress regimes.* Western Crop Science Society of America Annual Virtual Conference, Online. 7 July.
78. **Grover, K.*; Stovall, S. 2020.** *Integrating experiential learning in a crop production course.* North America Colleges and Teachers of Agriculture Virtual Conference, Online. 15-18 June.
79. **Gutierrez, P.; Khanal, S.; Seavert, C.; Teegerstrom, T. 2020.** *Economic impacts of producing alternative crop: guar, guayule and industrial hemp in New Mexico*. Alternative Crops Conference. Portales, New Mexico. 10 March.
80. **Hoare, D.M. 2018.** *Irrigation Sensors and the WINDS Model.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 26 September.
81. **Hoare, D.M.*; Katterman, M.; Waller, P. 2019.** *Development of a remote crop condition sensing system utilizing Internet of Things.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
82. **Huynh, T.*; Resendiz, M.; McMahan, C.; Dong, N. 2019.** *The Content and State of the In-Vitro Guayule Inventory in Tissue Culture and Opportunities to Improve our Methods*. Seminar Presentation and Discussion, USDA-ARS WRRC, Albany, California. 18 November.
83. **Idowu, O.J. 2018.** *Introduction to the SBAR Project*. Las Cruces, New Mexico. 6 Feb.
84. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Update*. Extension Field Day, Clovis, New Mexico. 9 August.
85. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Guar and Guayule*. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.
86. **Idowu, O.J.*; Pruitt, D. 2019.** *Sustainable Bio-economy for Arid Regions*. Extension Field Day. Fabian Garcia Research Center, Las Cruces, New Mexico. 26 June.
87. **Katterman, M. 2020.** *Guayule sensor and irrigation modeling + SBAR Education update*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 18 March.
88. **Khanal, S.*; Gutierrez, P. 2019.** *Farm-level impact analysis of growing guar (at 5% total acres adoption rate) in Dona Ana, New Mexico*. SBAR System Performance and Sustainability Team Seminar, Colorado State University, Ft. Collins, Arizona. 11 November.
89. **Khanal, S.*; Gutierrez, P.; Robbs, J.; Acharya, R. 2019.** *The Economic Potential of Producing Guayule in the Southwest.* Department of Agricultural Economics and Agricultural Business, New Mexico State University, Las Cruces, New Mexico. [poster]
90. **Khanal, S.; Gutierrez, P.; Seavert, C.; Teegerstrom, T. 2020.** *The economic impacts of producing guar using the input-output model.* New Mexico Alternative Crops Conference, Portales, New Mexico. 10 March. [poster]
91. **Khanal, S.; Gutierrez, P.; Seavert, C.; Teegerstrom, T. 2020.** *Guar research manuscript update.* SBAR System Performance and Sustainability Seminar. Colorado State University, Fort Collins, Colorado. 15 April.
92. **Khanal, S.; Seavert, C.; Gutierrez, P.; Teegerstrom, T.* 2019.** *The economic potential of producing guayule in the Southwest.* 31st Annual Meeting of the

Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]

93. **Ledesma, J.*; Ossanna, L; Pacido, D.; El-Shikha, D.E.; Dong, C.; Ponciano, G.; McMahan, C.; Neilson, J.W.; Maier, R.M. 2020.** *Associations between soil bioavailable phosphorus and guayule plant growth and rubber production*. 31st Annual Undergraduate Biology Research Program Conference, University of Arizona, Tucson, Arizona. 25 January.
94. **Ledesma, J.*; Ossanna, L; Pacido, D.; El-Shikha, D.E.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M.; Neilson, J.W. 2020.** *Associations between soil bioavailable phosphorus, phosphorus solubilizing microorganisms, and guayule growth stage and rubber production*. University of Arizona ENViSion Virtual Earth Week Conference, Tucson, Arizona. April. [poster]
95. **Leo, A. 2019.** *Microbial adaptations for arid regions and middle schoolers*. Institute for Energy Solutions (IES) Energy Talks public lecture series, Sky Bar, Tucson, Arizona. 14 March.
96. **Levy, T.*; Rock, C.; Idowu, O.J.; Dery, J.; Brassil, N.; Zozaya, S. 2019.** *Growers' perceptions and comprehension of biofuel, bioproducts, and guar in the Southwest Arid Region.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
97. **Lewis, M. 2019.** *Salt stress tolerance in guayule*. SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 23 October.
98. **Lewis, M.*; Judkins, A.; Teetor, V.H.; Ray, D.T. 2019.** *Evaluating guayule germplasm for salt tolerance.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
99. **Lohr, P. 2020.** *AquaCrop modeling of guayule*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 5 February.
100. **Lopez, E. 2018.** *Sustainable Bioeconomy for Arid Regions: Activities for education, extension and outreach*. American Institute of Chemical Engineers Rocky Mountain Regional Student Conference. Provo, Utah. 23 March.
101. **Lopez, E.*; Fox, S.; Brewer, C.E. 2018.** *GK-12 Lesson Documentation Spreadsheet*. American Institute of Chemical Engineers Annual Meeting, Pittsburg, Pennsylvania. 29 October.
102. **Maqsood, H. 2018.** *Guar Crop Coefficient Development for New Mexico Environments*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 7 November.
103. **Maqsood, H. 2020.** *Model parameterization for guar irrigation schedule and biomass estimation using remote sensing*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 1 April.
104. **Maqsood, H.*; Angadi, S.; El-Shikha, D.E.M.; Waller, P.; Singh, J.; Hunsaker, D.; Barua, B. 2019.** *Evaluating crop water status for guar using WINDS model.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
105. **Marinez, C.*; Lopez, G.U.; Cabrera D.d.J. 2019.** *The University of Arizona Cooperative Extension 4H Program Collaborating Statewide in Preparing the Next Generation of STEM Innovators.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
106. **McCloskey, W. 2018.** *Weed Trial Results for Guayule*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 14 November.

107. **McCloskey, W. 2019.** *Guayule Weed Control Research.* The 9th Annual Central Arizona Farmer Field Day. Maricopa Agricultural Center (MAC), Maricopa, Arizona. 8 October.
108. **McCloskey, W. 2020.** *2019 Herbicide Progress Report: Aim herbicide experiments and preemergence herbicide experiment failures*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 29 January.
109. **McMahan, C. 2018.** *Flowering Reduction in Guayule*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 19 September.
110. **McMahan, C. 2019.** *USDA-ARS Rubber Lab Update*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 27 March.
111. **McMahan, C.*; Placido, D.; El-Shikha, D.E.M.; Dong, C.; Ponciano, G.; Neilson, J.W. 2019.** *Dormancy and the guayule (Parthenium argentatum A. Gray) soil microbiome*. 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
112. **McMahan, C.*; Placido, D.; Resendiz, M.; Ponciano, G. 2020.** Flowering downregulation in guayule. Update to SBAR Advisory Board. Online presentation. 12 February.
113. **Mealing, V. 2018.** *An overview of sustainability analysis methods of a new biofuel feedstock: bagasse from guar*. 6th Colorado School of Mines Graduate and Discovery Symposium. Golden, Colorado. 5 April.
114. **Mealing, V. 2019.** *Criteria, Methods, Opportunities, and Needs for Social Sustainability of Emerging Technology*. 7th Colorado School of Mines Graduate Research and Discovery Symposium. Golden, Colorado. April.
115. **Mealing, V. 2019.** *Sustainability assessment of guayule agriculture: Potential processing improvements for guayule co-products*. USDA-ARS, Western Regional Research Center, Albany, California. 3 July. [invited speaker]
116. **Mealing, V. 2019.** *Field Data Collection and Integration*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 13 November.
117. **Mealing, V. 2020.** *Field data collection update*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 19 February.
118. **Mealing, V. 2020.** *Field data integration update*. SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 25 June.
119. **Mealing, V.*; Harris, T.; Landis, A.E. 2019.** *Criteria, Methods, Opportunities, and Needs for Social Sustainability of Emerging Technology*. 15th International Conference on Environmental, Cultural, Economic and Social Sustainability. Vancouver, Canada. February.
120. **Mealing, V.*; Summers, H.M.; Sproul, E.; Eranki, P.L.; Landis, A.E.; Quinn, J.C. 2018.** *Life Cycle Assessment of Cultivating Guar in the American Southwest*. LCA XVIII Conference. Fort Collins, Colorado. October [poster] Won second place in graduate student posters.
121. **Mealing, V.*; Summers, H.M.; Sproul, E.; Eranki, P.L.; Quinn, J.C.; Landis, A.E.. 2018.** *Life Cycle Assessment of Cultivating Guar in the American Southwest.* National Society of Black Engineers, Fall Regional Conference. Las Vegas, Nevada. November [poster]

122. **Mealing, V.S.*; Landis, A.E. 2019.** *Life cycle assessment of guar agriculture in the Southwest, USA.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
123. **Mealing, V.S.*; Landis, A.E. 2019.** *SBAR Sustainability.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
124. **Mi, W.*; Teetor, V.H.; Ray, D.T. 2018.** *Rubber and Resin Extraction of Differentially Treated Biomass in Guayule (Parthenium argentatum)*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
125. **Morris, N. 2020.** *SBAR 4-H opportunities and future directions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 19 February.
126. **Neilson, J.W. 2019.** *Soil Microbiome Resilience to Stress: How much is too much?* USDA-ARS, Western Regional Research Center, Albany, California. June. [invited speaker]
127. **Neilson, J.W.; Ossanna, L. 2020.** *Associations between the guayule rhizosphere microbiome and plant growth architecture, and rubber/resin production*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 4 March.
128. **Niu, D., 2018.** *Partial cloning of APETALA1 (AP1) gene from guayule*. cDNA Lab Seminar, USDA-ARS Western Regional Research Laboratory. 28 March.
129. **Ogden, K. 2017**. *Introducing new USDA NIFA CAP grant awardees – Developing regional AJF supply chains: Sustainable Bioeconomy for Arid Regions*. CAAFI-SOAP Jet Webinar. Hosted online. 13 October. [invited speaker]
130. **Ogden, K. 2017.** *Sustainable Bioeconomy for Arid Regions*. Biomass Research and Development Technical Advisory Board Meeting. 15 November. [invited speaker]
131. **Ogden, K. 2018.** *Sustainable Bio-economy for Arid Regions*. Southwest Indian Agricultural Association Annual Meeting. Laughlin, Nevada. 16-18 January.
132. **Ogden, K. 2018.** *Potential of the Bioproducts and Biofuels Economy*. AIChE Annual Meeting, Pittsburg, Pennsylvania. October [invited speaker]
133. **Ogden, K. 2020.** *Sustainable Bioeconomy for Arid Regions.* Grain Processing Lecture Series, Michigan Technological University, Houghton, Michigan. 17 January [invited speaker]
134. **Ogden, K. 2020.** *SBAR Project Update.* Southwest Indian Agriculture Association (SWIAA) 32nd Annual Conference, Laughlin, Nevada. 20-23 January [invited speaker]
135. **Ogden, K. 2020.** *Sustainable Bioeconomy for Arid Regions.* University of Utah, Salt Lake, Utah. 2 March. [invited distinguished lecturer]
136. **Ogden, K.*, White, R., Brewer, C.E. 2018.** *Public Private Partnerships*. ABLC Conference. Washington, D.C. 27-28 February.
137. **Ossanna, L.*; Placido, D.; El-Shikha, D.E.M.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M., Neilson, J.W. 2019.** *Root-zone microbiome dynamics and guayule rubber production*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
138. **Ponciano, G.*; Dong, N.; Placido, D.; Borg, K.; Fonseca, L.; Howard, C.; Shintani, D.; McMahan, C. 2019.** *Bioengineering of guayule (Parthenium argentatum) to enhance tocopherols content.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
139. **Pruitt, D.*; Idowu, O.J.; Sanogo, S.; Angadi, S.; Steiner, R.L. 2019.** *The effects of mycorrhizae inoculation and soil amendments on growth of guar and pinto beans*. ASA-CSSA-SSSA International Annual Meetings, San Antonio, Texas, 13 November.

140. **Resendiz, M. 2020.** *Flowering downregulation of Parthenium argentatum*. USDA-ARS Lab Meeting, Albany, California. 14 May.
141. **Rock, C.*, Brassill, N. 2018.** *Importance of Cooperative Extension in University Research*. University of Arizona, Tucson, Arizona. 14 March.
142. **Rogstad, A. 2018.** *Real World Supply Chain Development: USDA Coordinated Agriculture Projects. SBAR Overview*. CAAFI Biennial General Meeting and Integrated ASCENT Symposium. Washington, D.C. 4-6 December. [invited speaker]
143. **Rogstad, A**. **2019**. *SBAR Overview*. Association for the Advancement of Industrial Crops 31st Annual Meeting. Tucson, Arizona. 8 September. [invited speaker]
144. **Rodriguez-Uribe, L.*; Gutierrez, P. 2019.** *Implementing the Science of SBAR with Youth.* SBAR UA Research Team Seminar, University of Arizona, Tucson. 25 September.
145. **Rosalez, R.*; Brewer, C.E.; Jena, U. 2019.** *Co-Hydrothermal liquefaction (HTL) of guayue bagasse and wastewater treatment microalgae.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
146. **Sapkota, P.*; Imel, R.K.; Liu, W.; Angadi, S.; Trostle, C.; Williams, R.B.; Peffley, E.B.; Auld, D.L.; Burrow, M.D. 2019.** *Evaluation of breeding populations of guar for cultivation in Southwestern United States*. ASA-CSSA-SSSA International Annual Meetings, San Antonio, Texas, 12 November.
147. **Singh, J. 2020.** *Guar growth and development under pre-season and in-season irrigation management in the southern High Plains*. Master of Science Thesis. New Mexico State University, Las Cruces, New Mexico. 3 April.
148. **Singh, J**.*; **Angadi, S.V.; Begna, S.H. 2018**. *Crop Growth Stage Based Deficit Irrigation Management in Guar Crop.* The Western Sustainable Agriculture Conference (WSARE), University of New Mexico – Valencia Campus, Los Lunas, New Mexico. 12 December [poster]
149. **Singh, J.*; Angadi, S.V.; Begna, S.H. 2019.** *Identify guar germplasm suitable for cooler northern latitudes*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster] Won 2nd Place in graduate student poster presentation competition.
150. **Singh, J.*; Angadi, S.V.; Begna, S.H. 2020.** *Identify guar germplasm suitable for cooler northern latitudes of the Southern High Plains*. ***In***: Agricultural Science Center 2020 Annual Report. New Mexico State University, Clovis, New Mexico.
151. **Singh, J.*; Angadi, S.V.; Begna, S.H.; Guzman, I.; Idowu, O.J. 2019.** *Sustaining water resources using guar crop under different irrigation practices.* ACES-Open House, New Mexico State University, Las Cruces, New Mexico. 6 April. [poster]
152. **Singh, J.*; Angadi, S.V.; Begna, S.H.; Idowu, O.J. 2019.** *Guar as an alternative crop*. Annual Agricultural Field Day. Agricultural Science Center, Clovis, New Mexico. 8 August.
153. **Singh, J.*; Angadi, S.V.; Begna, S.H.; Idowu, O.J.; Guzman, I.; VanLeeuwen, D. 2019.** *Water extraction patters of guar under different irrigation strategies in the Southern High Plains.* Western Society of Crop Science Annual Meeting. Pasco, Washington. 25-26 June. [poster] Won 1st Place in student poster competition.
154. **Singh, J.*; Angadi, S.V.; Begna, S.H.; Idowu, O.J.; Guzman, I.; VanLeeuwen, D. 2019.** *Evaluating the effect of different irrigation practices on guar in the Southern High Plains.* Western Society of Crop Science Annual Meeting. Pasco, Washington. 25-26 June. Won 2nd Place in student oral presentation competition.

155. **Singh, J.*; Angadi, S.V.; Begna, S.H.; VanLeeuwen, D.; Idowu, O.J. 2019.** *Drought response and yield formation of guar under different water regimes in the Southern High Plains*. ASA-CSSA-SSSA International Annual Meetings, San Antonio, Texas. 10 November.
156. **Singh, J.*; Angadi, S.V.; Begna, S.H.; VanLeeuwen, D.; Idowu, O.J.; Guzman, I. 2020.** *Sustaining Irrigation Water of the Southern High Plains Using Guar*. New Mexico Alternative Crops Conference, Portales, New Mexico. 10 March. [poster]
157. **Skuse, K.*; Dery, J.; Zozaya, S.; Brassill, N.; Rock, C. 2018.** *Public interest in guayule being used as a biofuel.* University of Arizona, Maricopa Agricultural Center, Maricopa, Arizona. 26 July. [poster]
158. **Skuse, K.*; Dery, J.; Zozaya, S.; Brassill, N.; Rock, C. 2018.** *Public interest in guayule being used as a biofuel.* Oral presentation of student internship work. University of Arizona, Maricopa Agricultural Center, Maricopa, Arizona. 26 July.
159. **Smith, A. 2020.** *Valorization of guayule resin*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 22 April.
160. **Soliz, N.*; Brewer, C.E.; Jena, U.; 2019.** *Bomb calorimetry of guayule bagasse and hydrothermal liquefaction products.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
161. **Soto, A.L.*; Placido, D.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M.; Neilson, J.W. 2019.** *Soil parameters that influence natural rubber production in guayule (Parthenium argentatum) during winter dormancy*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster] Won 2nd Place in intern student poster presentation competition.
162. **Sproul, E. 2020.** *Integrated Economic & Environmental Analysis of Guayule and Guar Production*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 22 January.
163. **Sproul, E.*; Summers, H.M.*; Quinn, J.C. 2019.** *Techno-Economic and Environmental Impact Analysis of Guayule and Guar.* International Symposium on Sustainable Systems and Technology, Portland, Oregon. June. [poster] Won 1st Place in student poster competition.
164. **Sproul, E.*; Summers, H.M.; Mealing, V.; Landis, A.E.; Seavert, C.; Teegerstrom, T.; Gutierrez, P.; Robbs, J.; Fan, N.; Sun, O.; Quinn, J.C. 2019.** *Integrated environmental and economic assessment of guar and guayule.* American Center for Life Cycle Assessment (ACLCA) LCA XIX, Tucson, Arizona. 24-26 September. [poster]
165. **Sun, O. 2018.** *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty*. INFORMS Annual Meeting, Phoenix, Arizona. 5 November.
166. **Sun, O. 2018.** *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
167. **Sun, O. 2019.** *Optimization of a Biomass Supply chain from Economic, Environmental, and Social Perspectives*. Dr. Fan's Group Meeting, University of Arizona, Tucson, Arizona. 13 March.
168. **Sun, O. 2019.** *Biomass Supply Chain Configuration and Management*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 10 April.

169. **Sun, O. 2019.** *Integrating Environmental and Social Impacts into Biomass Supply Chain*. SBAR System Performance and Sustainability Team Seminar. Virtual meeting space, Tucson, Arizona. 2 May.
170. **Sun, O.*; Fan, N. 2018.** *Harvest scheduling*. SBAR Logistics Team Group Meeting. (webinar) New Mexico State University. Las Cruces, New Mexico. 5 February.
171. **Sun, O.*; Fan, N. 2018.** *Optimization of feedstock logistics*. SBAR UA Research Seminar. University of Arizona. Tucson, Arizona. 14 February.
172. **Sun, O.*; Fan, N. 2018.** *Optimally locating biorefineries*. SBAR Sustainability Working Group Seminar. (webinar) Colorado State University. Lakewood, Colorado. 8 March.
173. **Summers, H.M.*; Sproul, E.; Johnson, J.; Quinn, J.C. 2017.** *Sustainability assessment of bioproducts from southwest arid crops*. 21st Century Energy Transition Symposium, Colorado State University, Fort Collins, Colorado. October.
174. **Summers, H.M.*; Sproul, E.; Johnson, J.; Quinn, J.C. 2017.** *Sustainability assessment of bioproducts from southwest arid crops*. Colorado State University Graduate Student Showcase, Colorado State University, Fort Collins, Colorado. November.
175. **Summers, H.M.*; Sproul, E.; Johnson, J.; Quinn, J.C. 2018**. *Economic Viability and Environmental Impact of processing arid crops in the American Southwest.* International Congress on Environmental Modelling and Software. Colorado State University, Fort Collins, Colorado. June.
176. **Summers, H.M.*; Sproul, E.; Johnson, J.; Quinn, J.C. 2019.** *Economic and Environmental Impact Assessments of Drought Tolerant Crops in the American Southwest*. 21st Century Energy Transition Symposium, Denver, Colorado. April.
177. **Summers, H.M.*; Sproul, E.; Mealing, V.; Eranki, P.L.; Landis, A.E.; Quinn, J.C. 2018**. *Process Modeling and Life Cycle Assessment of Rubber from Guayule.* LCA XVIII Conference, Fort Collins, Colorado. October.
178. **Teegerstrom, T; Seavert, C. 2020.** *Whole farm analysis for evaluating the adoption of guayule and guar into Southwest producers' current operations*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 12 Februrary.
179. **Usrey, J.*; Dehghanizadeh, M.; Audu, M.; Rosalez, R. 2019.** *SBAR Education/Outreach at Lynn Middle School and Mesilla Valley Leadership Academy.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
180. **Waller, P. 2018.** *WINDS Model: A status report and connection to SBAR research*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 10 October.
181. **Wang, G.S.*; Lynch, A.; Cruz, V.M.V.; Dierig, D.A. 2019.** *Temperature requirements for guayule seed germination.* 31st Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
182. **Willmon, J.*, Hu, J., Teetor, V.H., and Ray, D.T. 2018.** *Screening Parthenium argentatum for resistance to Phymatotrichum omnivorum*. 2018 Annual Conference, American Society for Horticultural Science, Washington, D.C. 30 July – 3 August.
183. **Willmon, J.; Montes, M.*; Coronado, G.; Bennett, M.C.; Teetor, V.H.; Hu, J.; Ray, D.T. 2018**. *Screening Parthenium argentatum for Resistance to Phymatotrichum omnivora*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]

184. **Wright, A.*; Brewer, C.E.; Jena, U. 2019.** *CHNS elemental analysis of guayule and products.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
185. **Zuniga-Vasquez, D. 2019.** *Two-stage stochastic multi-objective optimization for biomass supply chain integrating environmental and social impacts.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
186. **Zuniga-Vasquez, D. 2019.** *Stochastic scenarios for guayule production*. SBAR System Performance and Sustainability Seminar, Colorado State University, Fort Collins, Colorado. 8 October.
187. **Zuniga-Vasquez, D. 2019.** *Stochastic multi-objective optimization for guayule supply chain integrating environmental and social impacts*. SBAR UA Research Seminar, University of Arizona, Tucson, Arizona. 4 December.
188. **Zuniga-Vasquez, D.; Fan, N. 2020.** *Optimization for guayule and guar logistics and transportation*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 19 February.
189. **Zuniga-Vasquez, D. 2020.** *Optimization for guayule and guar logistics and transportation*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 8 April.
190. **Zuniga-Vasquez, D.; Sun, O.; Fan, N. 2020.** *Optimization for guayule and guar logistics and transportation integrating environmental and social impacts on the supply chain.* New Mexico Alternative Crop Conference, Portales, New Mexico. 10 March. [poster]

Total Audience Demographics for Project-Related Presentations (when captured)

Audience Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
Gender			
Males	1,647	52	***1,699***
Females	753	38	***791***
Race/Ethnicity			
Hispanic	359	44	***403***
Asian	204	9	***213***
Native American	309	1	***310***
African American	63	0	***63***
Anglo/White	1,465	36	***1,501***

Audience Cumulative Total *(when captured)****: 2,490 ppl***

WEBSITE(S) OR INTERNET SITE(S)

SBAR Project Website

1. .https://sbar.arizona.edu

NEW TECHNOLOGIES OR TECHNIQUES GENERATED

None this reporting period.

INVENTIONS, PATENT APPLICATIONS, AND/OR LICENSES

1. **Dec 2017.** 24c SLN Label for Gramoxone SL 2.0 Herbicide (Paraquat dichloride), for control of weeds in guayule. SLN Registration Number: AZ120005. Expiration: 31 Dec 2022. Arizona Department of Agriculture, Environmental Services Division.

2. **Dec 2017.** 24c SLN Label for Fusilade DX Herbicide (*Propanoic acid, 2-(4-((5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)-, butyl ester, (R)-*), for control of emerged weeds in guayule. SLN Registration Number: AZ070006. Expiration: 31 Dec 2022. Arizona Department of Agriculture, Environmental Services Division.

OTHER PRODUCTS GENERATED

Brochures, Factsheets, and Flyers

1. **Duncan, C.M. 2018.** SBAR USDA-NIFA graduate student fellowship: UA Students. One page promotional flyer. February and March.
2. **Duncan, C.M. 2018.** SBAR USDA-NIFA graduate student fellowship: NMSU Students. One page promotional flyer. February and March.
3. **Duncan, C.M. 2018.** SBAR call for middle and high school science teachers. One page promotional flyer. February and March.
4. **Duncan, C.M. 2018.** SBAR 4-H summer camp: Biofuels powering your world. One page promotional flyer. March.
5. **Duncan, C.M. 2019.** SBAR Call for Middle & High School Science Teachers. One page promotional flyer. March.
6. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate student fellowship: UA Students. One page promotional flyer. March.
7. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate student fellowship: NMSU Students. One page promotional flyer. March.
8. **Duncan, C.**M. 2019. SBAR USDA-NIFA graduate science education fellowship. One page general recruiting flyer. April.
9. **Evancho, B. 2019.** Guayule Information & Feedback Session. One page invitation to attend field day and tour. May.
10. **Grover, K. 2018**. Guar – A potential alternative crop in New Mexico. Two page informational handout. January.
11. **Kiela, C. 2018.** Guayule. SBAR Project two-page fact sheet. March.
12. **Kiela, C. 2018.** Guar. SBAR Project two-page fact sheet. April.
13. **Kiela, C. 2018.** History of Guayule. SBAR Project two-page fact sheet. April.
14. **Rogstad, A. 2017.** SBAR – Sustainable Bioeconomy for Arid Regions. One-page informational and promotional card. November.

Press Releases and News Articles

1. 26 Sep 2017. “As NIFA awards $21.1M to grow the bioeconomy, CABLE debuts to bridge students and industry.” BiofuelsDigest.

http://www.biofuelsdigest.com/bdigest/2017/09/26/as-nifa-awards-21-1m-to-grow-the-bioeconomy-cable-debuts-to-bridge-students-and-industry/

2. 16 Oct 2017. "UA to Head New Center Focusing on Biofuels and Bioproducts." UA News. https://uanews.arizona.edu/story/ua-head-new-center-focusing-biofuels-and-bioproducts

3. 4 Nov 2017. "Biofuels, bioproducts, and an Arizona bioeconomy?" Arizona Daily Wildcat. http://www.wildcat.arizona.edu/article/2017/11/science-biofuels-and-bioproducts

4. 29 Nov 2017. "NMSU to host state sustainable agriculture conference in Los Lunas." News Bulletin. http://www.news-bulletin.com/news/nmsu-to-host-state-sustainable-agriculture-conference-in-los-lunas/article_a45281f6-d540-11e7-9530-27dc93258a79.html

5. 16 Jan 2018. "Dr. Quinn's Sustainability Expertise Recruited for Multi-Million Dollar DOE and USDA Grants." Colorado State University, Mechanical Engineering Featured Projects. http://www.engr.colostate.edu/me/2018/01/16/dr-quinns-sustainability-expertise-recruited-for-multi-million-dollar-doe-and-usda-grants/

6. 21 Feb 2018. "NMSU collaborating in Sustainable Bio-economy for Arid Regions project." New Mexico State University News Center. http://newscenter.nmsu.edu/Articles/view/12961/nmsu-collaborating-in-sustainable-bio-economy-for-arid-regions-project

7. 27 Feb 2018. "Bridgestone receives guayule research grant from USDA." The Smithers Report - A daily and weekly tire industry news source. (4,500 daily subscribers) https://www.smithersrapra.com/publications/the-smithers-report

8. 27 Feb 2018. "Bridgestone and research partners earn $15 Million grant for guayule work." MTD (Modern Tire Dealer). UMV: 62,085. http://www.moderntiredealer.com/news/728673/bridgestone-and-research-partners-earn-15-million-grant-for-guayule-work

Tabling Events and Workshops – Marketing and Outreach

1. 14 July 2017. New Mexico Cotton Ginners Conference. New Mexico.
2. 17 Aug 2017. SBAR Project Kick-off Meeting. Tucson, Arizona.
3. 28 Oct 2017. Rocky Mountain Zone Summit (sustainability focus). Denver, Colorado.
4. 05 Dec 2017. Valencia County (New Mexico) Forage Conference. New Mexico.
5. 13 Dec 2017. New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico.
6. 15-17 Feb 2018. SBAR Display Table. New Mexico Organic Farming Conference. Albuquerque, New Mexico.
7. 24 Feb 2018. Farm Science Day. USDA-ARS, Arid-Land Agricultural Resource Center. Maricopa, Arizona.
8. 24 Feb 2018. 2018 Engineering Fair – Recycled papermaking and guar gum bubbles activity. Las Cruces Museum of Science and Nature. Las Cruces, New Mexico.

9. 15 Mar 2018. Zia Middle School Project – Lead the Way NMSU College of Engineering Day. Recycled papermaking and guar gum bubbles activity. Las Cruces, New Mexico.
10. 22-24 Feb 2018. Southwest Ag Summit. Yuma, Arizona.
11. 19 Mar 2018. Roosevelt Irrigation District Board Meeting. Buckeye, Arizona.
12. 28 Mar 2018. Alfalfa and Forage Workshop. Maricopa, Arizona.
13. 11 Jul 2018. New Mexico 4-H State Conference – Polymerization and guar gum bubbles activity. Albuquerque, New Mexico.
14. 9 Aug 2018. Extension Field Day, New Mexico State University Agricultural Science Center, Clovis, New Mexico.
15. 23 Aug 2018. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico.
16. 12 Dec 2018. New Mexico Sustainable Agriculture Conference, Las Cruces, New Mexico.
17. 10 Jan 2019. Marana Winter Field Crop Clinic. University of Arizona Cooperative Extension, Marana, Arizona.
18. 15 Jan 2019. Casa Grande Winter Field Crop Clinic. University of Arizona Cooperative Extension, Casa Grande, Arizona.
19. 23 Jan 2019. New Mexico Cotton Growers Association Conference, Ruidoso, New Mexico.
20. 13 Feb 2019. Desert Hills S.T.E.A.M. Night. (Science, Technology, Engineering, Art, and Math) Desert Hills Elementary School, Las Cruces, New Mexico.
21. 15-16 Apr 2019. New Mexico Organic Farming Conference, Albuquerque, New Mexico.
22. 11 Apr 2019. Spring Extension Field Day, New Mexico State University Agricultural Science Center, Clovis, New Mexico.
23. 15 May 2019. Annual Agricultural Research Congressional Exhibition and Reception. Rayburn House, Washington, D.C.
24. 30 May 2019. Market Discussion and Field Day. Bridgestone Guayule Research Farm, Eloy, Arizona.
25. 26 Jun 2019. Extension Field Day. Fabian Garcia Research Center, Las Cruces, New Mexico.
26. 2 Jul 2019. SBAR Train the Trainers Workshop. Las Cruces, New Mexico.
27. 8 Aug 2019. Annual Agricultural Field Day. Agricultural Science Center, Clovis, New Mexico.
28. 8 Aug 2019.Agricultural Science and Field Day. Agricultural Science Center, Tucumcari, New Mexico.
29. 15 Aug 2019. Annual Agricultural Field Day. Agricultural Science Center, Los Lunas, New Mexico.
30. 21 Aug 2019. USAID Cochran Fellows Visit from Mali, Clovis, New Mexico.
31. 12 Oct 2019. Cooperative Extension Day. Maricopa Agricultural Center (MAC), Maricopa, Arizona.
32. 14 Jan 2020. Winter Field Crops Meeting, Pima County, Arizona.
33. 15 Jan 2020. Winter Field Crops Meeting, Pinal County, Arizona.
34. 29 Jan 2020. New Mexico Cotton Grower's Conference, New Mexico.
35. 30 Jan 2020. NexGen Cotton Symposium, Pinal County, Arizona.
36. 3-4 Feb 2020. New Mexico Chili Pepper Conference, New Mexico.
37. 5 Feb 2020. Deltapine Seed Meeting, Pinal County, Arizona.
38. 21-22 Feb 2020. New Mexico Organic Farming Conference, New Mexico.

39. 10 Mar 2020. New Mexico Alternative Crops Conference, Portales, New Mexico.

→Total Reach via Tabling Events and Workshops (when captured): ***3,562 participants***

YOUTH ACTIVITIES

Biofuel Lessons in Classrooms (SBAR Teacher/Fellow Cohort 2018-2019)

1. Apollo Middle School, Tucson, Arizona.
2. Mesilla Valley Leadership Academy, Las Cruces, New Mexico.
3. Pueblo High School, Tucson, Arizona.
4. Quail Run Elementary School, Marana, Arizona.
5. Sierra Middle School, Las Cruces, New Mexico.
6. Valencia Middle School, Tucson, Arizona.
7. Walter Douglas Elementary School, Tucson, Arizona.

Biofuel Lessons in Classrooms (SBAR Teacher/Fellow Cohort 2019-2020)

1. Apollo Middle School, Tucson, Arizona.
2. Camino Real Middle School, Las Cruces, New Mexico.
3. Mesa Middle School, Las Cruces, New Mexico
4. Mesilla Valley Leadership Academy, Las Cruces, New Mexico.
5. Quail Run Elementary School, Marana, Arizona.
6. Pueblo High School, Tucson, Arizona.
7. Saguaro National Park Environmental Education, Tucson, Arizona.
8. Santa Rosa Ranch School, Sells, Arizona.
9. Sierra Middle School, Las Cruces, New Mexico.
10. Walter Douglas Elementary School, Tucson, Arizona.

Youth participation through classroom activities is tracked at the beginning of the school year in September because the same students are being reached each week by the teacher fellow pairs.

Other SBAR youth activities (4H camps, after school programs, Native Youth Outreach, etc.) are also included in the total when they occur.

Youth Participation Demographics for Project-Related Activities (when captured)

Youth Participation Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
Age Level			
11-13 years	1,242	0	***1,242***
14-16 years	433	40	***473***
Gender			
Males	834	24	***858***
Females	841	16	***857***
Race/Ethnicity			
Hispanic	893	3	***896***

Asian	33	0	***33***
Native American	159	24	***183***
African American	47	0	***47***
Anglo/White	538	5	***543***
Multiracial	6	8	***14***

Youth Cumulative Total *(when captured)****: 1,715 ppl***

PARTICIPANTS AND COLLABORATING ORGANIZATIONS. September 2017 – June 2020

PARTNER ORGANIZATIONS

Organization Person*	Project Role	Project Component
Bridgestone Americas,		
Von Mark Cruz	Professional	Feedstock Development & Production
David Dierig	Key Collaborator	Feedstock Development & Production
Stefan Dittmar	Professional	Feedstock Development & Production
Chloe Gonzalez	*Intern*	*Feedstock Development & Production*
Amber Lynch	Professional	Feedstock Development & Production
Russell Prock	Professional	Feedstock Development & Production
Theresa Sullivan	Professional	Feedstock Development & Production
Sam Wang	Professional	Feedstock Development & Production
Jocelyn Zhu	*Intern*	*Feedstock Development & Production*
Colorado School of Mines		
Pragnya Eranki	*Post-doc*	*System Performance & Sustainability*
Amy Landis	Key Collaborator	System Performance & Sustainability
VeeAnder Mealing	Graduate Student	System Performance & Sustainability
Colorado State University		
Austin Banks	Undergrad Student	System Performance & Sustainability
Jack Johnson	*Undergrad Student*	*System Performance & Sustainability*
Paula Mendoza Moreno	Undergrad Student	System Performance & Sustainability
Jason Quinn	Key Collaborator	System Performance & Sustainability
Evan Sproul	Graduate Student	System Performance & Sustainability
Hailey Summers	Graduate Student	System Performance & Sustainability
New Mexico State University		
Ram Acharya	*Professional*	*System Performance & Sustainability*
Sarah Acquah	*Post-doc*	*Extension & Outreach* *System Performance & Sustainability*
Rowen Allen	Undergrad Student	Extension & Outreach
Sangu Angadi	Key Collaborator	Extension & Outreach Feedstock Development & Production
Matt Armijo	Undergrad Student	Characterizations & Co-Products
Meshack Audu	*Graduate Student Fellow*	*Education* *Characterizations & Co-Products*
Valerie Bailey	*Undergrad Student*	*Feedstock Development & Production*
Hengameh Bayat	Graduate Student	Characterizations & Co-Products
Sultan Begna	*Professional*	*Feedstock Development & Production*
Geneva Ben	*Undergrad Student*	*Feedstock Development & Production*
Pratima Bhandari	*Graduate Student*	*System Performance & Sustainability*
Catherine E. Brewer	Key Collaborator	Education Characterizations & Co-Products
Nicolas Carrero-Little	Undergrad Student	Characterizations & Co-Products

Pedro Castillo	Undergrad Student	Feedstock Development & Production
Kenneth Cazarez	Undergrad Student	Extension & Outreach
Shivam Chawla	Graduate Student	Feedstock Development & Production
Feng Cheng	Post-doc	Characterizations & Co-Products
Murali Darapuneri	Professional	Extension & Outreach
Mostafa Dehghanizadeh	Graduate Student Fellow	Education Characterizations & Co-Products
Barry Dungan	*Professional*	*Characterizations & Co-Products*
Dominic Flores	Undergrad Student	Feedstock Development & Production
Miguel Flores	*Undergrad Student*	*Extension & Outreach*
Leonel Fournier	Undergrad Student	Feedstock Development & Production
Sarah Fox	*Undergrad Student*	*Characterizations & Co-Products*
Ryan Fullerton	Undergrad Student	Feedstock Development & Production
Claudia Galvan	Professional	Characterizations & Co-Products
Alonso Garcia	*Graduate Student*	*Feedstock Development & Production*
Adah Gellis	*Undergrad Student*	*Extension & Outreach*
Saba Gill	*Graduate Student*	*Characterizations & Co-Products*
Thomas Gloria	*Undergrad Student*	*Feedstock Development & Production*
Kulbhushan Grover	Key Collaborator	Extension & Outreach Feedstock Development & Production
Erin Gutierrez	Undergrad Student	Characterizations & Co-Products
Maria Gutierrez	Undergrad Student	Extension & Outreach
Paul H Gutierrez	Key Collaborator	Extension & Outreach System Performance & Sustainability
Befekadu Habteyes	*Professional*	*System Performance & Sustainability*
Jose Hackleen	Undergrad Student	Feedstock Development & Production
F. Omar Holguin	Key Collaborator	Characterizations & Co-Products
John Idowu	Key Collaborator	Extension & Outreach
Jackie Jarvis	Professional	Characterizations & Co-Products
Umakanta Jena	Professional	System Performance & Sustainability
Sita Khanal	Graduate Student	System Performance & Sustainability
Alix Knagg	Undergrad Student	Characterizations & Co-Products
Kelly Laje	Graduate Student	Characterizations & Co-Products
Travis Le-Doux	*Undergrad Student*	*Characterizations & Co-Products*
Esai Lopez	*Undergrad Student*	*Education*
Alberto Lorenzo	*Undergrad Student*	*Feedstock Development & Production*
Sicilee Macklin	*Undergrad Student*	*Education* *Characterizations & Co-Products*
Michael Mares	Undergrad Student	Extension & Outreach
Cesar Martinez-Bejarano	Undergrad Student	Characterizations & Co-Products
Frannie Miller	Professional	Extension & Outreach
Julie Miller	*Undergrad Student*	*Extension & Outreach*
Sa'Rae Montoya	*Graduate Student*	*Characterizations & Co-Products*
Kyle Moore	*Undergrad Student*	*Feedstock Development & Production*
Hasti Mozaffari	Graduate Student	Characterizations & Co-Products
Mohammed Omer	Graduate Student	Extension & Outreach
Jasmine Paquin	*Graduate Student*	*Extension & Outreach*
Kaavya Polisetti	*Graduate Student*	*Characterizations & Co-Products*
Camila Prieto	*Undergrad Student*	*Extension & Outreach*
Darien Pruitt	Graduate Student Fellow	Education Extension & Outreach
Jason Quintana	Undergrad Student	Extension & Outreach
Lucas Ramirez	*Undergrad Student*	*Feedstock Development & Production*
Joram Robbs	*Graduate Student*	*Extension & Outreach*

		System Performance & Sustainability
Laura Rodriguez-Uribe	Professional	Extension & Outreach Characterizations & Co-Products
Alvaro Romero	Professional	Characterizations & Co-Products
Rodrigo Rosalez	Graduate Student Fellow	Education Characterizations & Co-Products
Kimberly Salinas	*Undergrad Student*	*Extension & Outreach*
Nathan Schavz	*Undergrad Student*	*Characterizations & Co-Products*
Tarah Schuman	*Undergrad Student*	*Characterizations & Co-Products*
Ujala Sehar	Graduate Student	Characterizations & Co-Products
Sergei Shalygin	Graduate Student	Characterizations & Co-Products
Jagdeep Singh	Graduate Student	Education Feedstock Development & Production
Parameer Singh	Graduate Student Fellow	Feedstock Development & Production Education
Peter Skelton	*Professional*	*Extension & Outreach*
Nicolas Soliz	Undergrad Student	Characterizations & Co-Products
Grant Stoner	Undergrad Student	Feedstock Development & Production
David Struthers	Undergrad Student	Feedstock Development & Production
Stephen Taylor	*Undergrad Student*	*Education*
Brian Treftz	*Graduate Student*	*Education* *Characterizations & Co-Products*
Stephanie Torres	Graduate Student	Feedstock Development & Production
Jacob Usrey	Graduate Student Fellow	Education Characterizations & Co-Products
Justin Valdez	*Undergrad Student*	*Characterizations & Co-Products*
Victoria Valenzuela	Undergrad Student	Feedstock Development & Production
Stephanie Willette	*Graduate Student*	*Characterizations & Co-Products*
Scott Woolf	*Undergrad Student*	*Characterizations & Co-Products*
April Wright	Undergrad Student	Characterizations & Co-Products
Other		
Jennifer Fields	Professional	Education Extension & Outreach
Clark Seavert	Professional	System Performance & Sustainability Extension & Outreach
University of Arizona		
Torran Anderson	Professional	Education Extension & Outreach
Nick Ashley	*Graduate Student*	*Feedstock Development & Production*
Craig Bal	*Graduate Student*	*Education* *Extension & Outreach*
Gloria Villa Barbosa	*Undergrad Student*	*Extension & Outreach*
Armando Barreto	Professional	Feedstock Development & Production
Holly Barton	*Graduate Student Fellow*	*Education*
Kaitlyn Benally	*Undergrad Student*	*Extension & Outreach*
Megan Bennett	*Undergrad Student*	*Feedstock Development & Production*
Natalie Brassill	Professional	Extension & Outreach
Kyle Brown	Graduate Student	Feedstock Development & Production
Kale Burke	Undergrad Student	Characterizations & Co-Products
Daniela Cabrera	*Professional*	*Extension & Outreach*
Madasu Chandrashekar	Professional	Characterizations & Co-Products

Connor Chaney	Undergrad Student	Feedstock Development & Production
Sara Chavarria	Key Collaborator	Education
Yongjian Chen	Post-doc	Feedstock Development & Production
German Coronado	*Undergrad Student*	*Feedstock Development & Production*
Kamel Didan	*Professional*	*Feedstock Development & Production*
Cara Duncan Shopa	Professional	Education Extension & Outreach
Diaa El-Shikha	Post-doc	Feedstock Development & Production
Blase Evancho	Key Collaborator Graduate Student	Extension & Outreach Feedstock Development & Production
Neng Fan	Key Collaborator	System Performance & Susainability
Krista Farmer	*Undergrad Student*	*Feedstock Development & Production*
Charles Ferini	Undergrad Student	Feedstock Development & Production
Gunnar Fritz	*Undergrad Student*	*Education*
Daryan Godfrey	*Undergrad Student*	*Feedstock Development & Production*
Leslie Gunatilaka	Key Collaborator	Characterizations & Co-Products
Wolfgang Grunberg	Professional	ALL AREAS
Matthew Harmon	*Undergrad Student*	*Feedstock Development & Production*
Danielle Hoare	Graduate Student	Feedstock Development & Production
Stephanie Honeker	*Undergrad Student*	*Feedstock Development & Production*
Arisbeth Ibarra Nieblas	Graduate Student Fellow	Education
Aaron Judkins	Undergrad Student	Feedstock Development & Production
Pujan Kafle	*Graduate Student*	*System Performance & Sustainability*
Matthew Katterman	Graduate Student Fellow	Education Feedstock Development & Production
C. Kasia Kiela	*Undergrad Student*	*ALL AREAS*
Corey Knox	Professional	Education
Jessica Ledesma	Undergrad Student	Feedstock Development & Production
Ashton Leo	*Graduate Student Fellow*	*Education*
Taylor Levy	*Intern*	*Extension & Outreach*
Myles Lewis	Professional	Feedstock Development & Production
Manping Liu	Professional	Characterizations & Co-Products
Patrick Lohr	Graduate Student	Feedstock Development & Production
Gerardo Lopez	*Key Collaborator*	*Extension & Outreach*
Jasmine Lopez	*Undergrad Student*	*Extension & Outreach*
Raina Maier	Key Collaborator	Feedstock Development & Production
Jonathan Maldonado	Undergrad Student	Feedstock Development & Production
Hadiqa Maqsood	Graduate Student	Feedstock Development & Production
Celestina Marinez	*Intern*	*Extension & Outreach*
William McCloskey	Key Collaborator	Feedstock Development & Production
Wenzhe Mi	*Intern*	*Feedstock Development & Production*
Istvan Molnar	Key Collaborator	Characterizations & Co-Products Education
Madison Montes	*Undergrad Student*	*Feedstock Development & Production*
Leobardo Moreno	Undergrad Student	Feedstock Development & Production
Madison Morris	Undergrad Student	Feedstock Development & Production
Nick Morris	Key Collaborator	Extension & Outreach
Julie Neilson	Professional	Feedstock Development & Production
Andrew Nelson	*Post-doc*	*Feedstock Development & Production*
Kim Ogden	Key Collaborator	ALL AREAS
Huitzilin Ortiz	Graduate Student Fellow	Education

Lia Ossanna	Professional	Feedstock Development & Production
Bryan Pastor	Professional	Feedstock Development & Production
Duke Pauli	*Key Collaborator*	*Feedstock Development & Production*
Livvi Pearson	Undergrad Student	Feedstock Development & Production
Alexandra Peck	Undergrad Student	Feedstock Development & Production
Shaira Perez	*Undergrad Student*	*Extension & Outreach*
Sam Pernu	*Undergrad Student*	*Feedstock Development & Production*
Tenzin Phakdon	Graduate Student Fellow	Education
Sarocha Pradyawong	Post-doc	Feedstock Development & Production
Dennis T. Ray	Key Collaborator	Feedstock Development & Production
Jaspreet Rekhi	*Professional*	*Characterizations & Co-Products*
Channah Rock	Key Collaborator	Extension & Outreach
Alix Rogstad	Professional	ALL AREAS
Juan Salas	Undergrad Student	Feedstock Development & Production
Luis Anguiano Sanchez	*Professional*	*Feedstock Development & Production*
Carl Schmalzel	Professional	Feedstock Development & Production
Rebecca Sheng	Undergrad Student	Feedstock Development & Production
Stephanie Sikora	*Professional*	*Education*
Andrew Smith	Graduate Student	Feedstock Development & Production
Ana Lucia Soto	*Undergrad Student Intern*	*Feedstock Development & Production*
Seth Steichen	Graduate Student Fellow	Education
Ou Sun	*Graduate Student*	*System Performance & Sustainability*
Trent Teegerstrom	Key Collaborator	Extension & Outreach System Performance & Sustainability
Valerie Teetor	Professional	Feedstock Development & Production
Mira Theilmann	*Undergrad Student*	*Feedstock Development & Production*
Christine Toering	*Undergrad Student*	*Feedstock Development & Production*
Gianni Velasco	*Undergrad Student*	*Feedstock Development & Production*
Peter Waller	Key Collaborator	Feedstock Development & Production
Quinn Waltz	*Undergrad Student*	*Feedstock Development & Production*
John Willmon	*Undergrad Student*	*Feedstock Development & Production*
Ya-ming Xu	Post-doc	Characterizations & Co-Products
Ali Yaylali	Graduate Student Fellow	Education
Stevi Zozaya	Undergrad Student	Extension & Outreach
Daniel Zuniga-Vazquez	Graduate Student	Characterizations & Co-Products System Performance & Sustainability
USDA Agriculture Research Service – US Arid Lands Research Center, Maricopa AZ		
Hussein Abdel-Haleem	Key Collaborator	Feedstock Development & Production
Adrianna Chambers	*Undergrad Student*	*Feedstock Development & Production*
Amber Dearstyne	*Undergrad Student*	*Feedstock Development & Production*
Tristan Dunton	*Professional*	*Feedstock Development & Production*
Harmony Glover	*Undergrad Student*	*Feedstock Development & Production*
Doug Hunsaker	*Professional*	*Feedstock Development & Production*
Greg Leake	*Professional*	*Feedstock Development & Production*
Avery Luna	Undergrad Student	Feedstock Development & Production
Aaron Szczepanek	Professional	Feedstock Development & Production
Brandon Vera	*Undergrad Student*	*Feedstock Development & Production*
USDA Agriculture Research Service – Western Regional Research Center, Albany CA		

Milagro Adom	*Student (SEED)*	*Feedstock Development & Production*
Sheyla Aucar	*Professional*	*Feedstock Development & Production*
Brandon Bartelmie	Professional	Feedstock Development & Production
Matthew Canonizado	*Professional*	*Feedstock Development & Production*
George Chong	*Professional*	*Feedstock Development & Production*
Chen Dong	Professional	Feedstock Development & Production
Niu Dong	Professional	Feedstock Development & Production
Trinh Huynh	Professional	Feedstock Development & Production
Kumiko Johnson	Professional	Feedstock Development & Production
Colleen McMahan	Key Collaborator	Feedstock Development & Production
Dante Placido	Post-doc	Feedstock Development & Production
Grisel Ponciano	Professional	Feedstock Development & Production
Mariano Resendiz	Graduate Student	Feedstock Development & Production

** Individuals no longer actively working on the SBAR project appear in italic.*

Total Active Key Collaborators: ***23***
Total Active Professional Staff: ***38***
Total Active Postdoctoral Researchers: ***6***
Total Active Graduate Students: ***29***
Total Active Undergraduate Students: ***36***
Total Active Fellows: ***11***
Total Active /Interns: ***0***

*Total Active Participants:****142***
Total Past Participants (no longer active): ***82***
Total Individuals Involved Since SBAR Inception: ***224***

COLLABORATIONS AND OTHER CONTACTS

Collaborations:

Academic Institutions:	CSM (Colorado School of Mines) - Dept. of Civil and Environmental Engineering CSU (Colorado State University) - Dept. of Mechanical Engineering FSU (Florida State University) - National High Magnetic Field Laboratory NMSU (New Mexico State University) - Cooperative Extension - Dept. of Agricultural Economics and Agricultural Business - Dept. of Chemical and Materials Engineering - Dept. of Plant and Environmental Sciences UA (University of Arizona) - Agricultural and Biosystems Engineering - College of Agriculture and Life Sciences - College of Education - College of Engineering - Cooperative Extension - Dept. of Agriculture and Resource Economics - Dept. of Chemical and Environmental Engineering - Dept. of Language, Reading and Culture - Dept. of Soil, Water and Environmental Sciences - Dept. of Systems and Industrial Engineering - Dept. of Teaching and Teacher Education - Institute of Energy Solutions - Natural Products Center - School of Natural Resources and the Environment - School of Plant Sciences UNM (University of New Mexico) – Gallup - Dept. of Mathematics, Physical and Natural Science
Nonprofits:	
Industrial or Commercial Firms:	BASF Bridgestone Americas, Inc. Central Arizona Project (CAP) FMC Guar Resources Syngenta

Federal Government	Saguaro National Park (West), Tucson AZ - Environmental Education Department USDA – Agricultural Research Service, Western Regional Research Center, Albany CA - Chemistry (Bioproducts) - Plant Genetics USDA – Agricultural Research Service, Grassland Soil and Water Research Laboratory, Temple TX - Crop Modeling
State or Local Governments:	Arizona Department of Agriculture, Environmental Services Division
Tribal Governments:	
Schools or School Systems:	**BASIS Charter Schools**, BASIS Tucson North (high school), Tucson, Arizona **Flowing Wells Unified District**, Walter Douglas Elementary School, Tucson, Arizona **Las Cruces Public Schools**, Camino Real Middle School, Mesa Middle School, Mesilla Valley Leadership Academy, and Sierra Middle School, Las Cruces, New Mexico **Marana Unified School District**, Quail Run Elementary School, Marana, Arizona **Tucson Unified School District**, Pueblo High School, and Valencia Middle School, Tucson, Arizona **Santa Rosa Ranch School District**, Santa Rosa Ranch School, Sells, Arizona **Sunnyside Unified School District**, Apollo Middle School, Tucson, Arizona
Other Organizations (foreign or domestic):	

Other Contacts:

Contacts with others within recipient's organization (interdepartmental or interdisciplinary collaborations):	UA (University of Arizona) - Applied Biosciences - Arid Lands Resource Sciences - College of Agriculture and Life Sciences - College of Architecture, Planning and Landscape Architecture - College of Science

	- Institute of the Environment - Water Resources Research Center
Contacts with others outside the organization:	Denver Museum of Nature and Science, Denver Colorado Central Arizona College
Contacts with others outside the United States or with an international organization:	

APPENDICES

APPENDIX 1. EXTENSION OUTREACH EVENTS

Documents Included

1. **UArizona Cooperative Extension – New Technologies Workshop for Field Crops** – Full meeting agenda for virtual event. 3 June 2020. (1p)

THE UNIVERSITY OF ARIZONA
Cooperative Extension
Field Crops

AGENDA

The 7th Annual New Technologies Workshop for Field Crops

Wednesday, June 3rd, 2020 – 9:00 AM – 12:30 PM MST

Via ZOOM

Click HERE to Register

9:00	**Dr. Ayman Mostafa**	**Introduction to Zoom** **Chemistries for Alfalfa Insect Pest Management**
9:20	**Dr. Calvin Trostle**	**Guar as a Possible Desert Tolerant Legume in the U.S. Southwest**
9:40	**Andrea Carter**	**Industrial Hemp: Overview and Research Opportunities**
10:00	**Dr. Bindu Poudel**	**Hemp Diseases: Diagnosis and Management**
10:20	**Dr. Peter Ellsworth** **Ms. Naomi Pier and** **Ms. Isadora Bordini**	**Push-Pull-Control: Securing Guayule's Future**
10:40	**Dr. Bill McCloskey**	**Progress Towards Managing Weeds in Guayule**
11:00	**Dr. Sam Wang**	**Establishing a Natural Rubber Industry from Guayule in Arizona**
11:20	**Dr. Oli Bachie**	**Rhodes Grass: A New Forage Crop for the Low Desert**
11:40	**Dr. Randy Norton**	**An Update on Western SARE**
12:00		**Industry Updates**

Questions? Please contact
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