



SUSTAINABLE BIOECONOMY FOR ARID REGIONS (SBAR)

Summary Report – Quarter 4, 2019

Information submitted by project partners; synthesized by:
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USDA Cover Page

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ACCOMPLISHMENTS

October 2019 – December 2019

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 manages 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, continues to be effective at 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 will be 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 is 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.

Now that SBAR research is fully underway, the Advisory Board will be meeting more 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.

The Advisory Board met in November, where the Feedstock Development & Production – Irrigation Team provided an overview and status update on the research progress as well as a briefing for a new irrigation study that will be initiated in early spring 2020. The Advisory Board was also able to learn more and ask direct questions to the researchers regarding remote sensing data and process, effective irrigation strategies for guayule production, and water needs for guar production in New Mexico. Future Advisory Board meetings will be hosted in January, February, April, and May 2020.

Budget and Financial Management

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

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.

To clarify the budget reallocation process and address specific questions that have been raised regarding the use of SBAR project funds, a reference document (Budget Guidelines) was developed by Rogstad and approved by the SBAR Leadership Team in October. (Appendix 1) The document has been shared broadly among the SBAR Team for future reference.

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. During this reporting period, the virtual meeting space (via Zoom) was utilized 34 times for over 38.13 hours. An additional 15 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.



Photo 1. SBAR Team at the Annual Retreat at the University of Arizona in Tucson, Arizona, September 2019.

SBAR Annual Retreat

As previous years, the 2020 SBAR Annual Retreat will be hosted at the University of Arizona in Tucson from 27-29 July 2020. The Retreat will include progress updates for each Component, Advisory Board meeting time, and open networking periods. There will also be multiple opportunities for student engagement through dialogue with colleagues and poster presentations. We are tentatively planning for Component-specific sessions following the joint retreat. Preparation and pre-planning for the Annual Retreat is underway; a final agenda will be available by June.

Communication and Reporting

Rogstad continues to be the main point-of-contact for most SBAR communication. Various listservs are maintained that enables 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.

The SBAR webpage was visited by people in 38 different states of the USA during this reporting period (Table 2). Since inception, the website has been viewed by people in 41 states.

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

State	Time Period				
	Jul – Dec 2018	Jan – Mar 2019	Apr – Jun 2019	Jul – Sep 2019	Oct – Dec 2019
Arizona	X	X	X	X	X
Arkansas				X	
California	X	X	X	X	X
Colorado	X	X	X	X	X
Delaware					X
District of Columbia	X	X		X	
Florida		X	X		X
Georgia				X	X
Idaho					X
Illinois	X	X	X	X	X
Indiana		X			X
Iowa	X	X	X	X	X
Kansas	X		X		X
Kentucky					X
Maryland	X				X
Massachusetts			X	X	X
Michigan		X	X		X
Minnesota			X	X	X
Mississippi					X
Missouri				X	X
Montana				X	X
Nebraska				X	X
Nevada				X	X
New Mexico	X	X	X	X	X
New York	X	X	X	X	X
North Carolina	X				X
North Dakota					X
Ohio		X	X	X	X
Oklahoma					X

State	Time Period				
	Jul – Dec 2018	Jan – Mar 2019	Apr – Jun 2019	Jul – Sep 2019	Oct – Dec 2019
Oregon			X	X	X
Pennsylvania		X			X
South Carolina	X		X		
South Dakota					X
Tennessee	X	X	X	X	X
Texas	X	X	X	X	X
Utah					X
Virginia		X	X	X	X
Washington	X	X	X	X	X
West Virginia					X
Wisconsin		X		X	X
Wyoming		X	X	X	X
Total	15	19	20	24	38

There were 811 unique sessions from October – December 2019. Page views occurred in 33 different countries this quarter (top two: USA and India), including 11 countries that have not visited the website previously. Even though website visitors are diversifying, visitors from the USA, India, Iran, China, Mexico, and Pakistan account for about 90% of site visits overall.

There have been 5,246 unique website sessions since July 2018. Since activation, the website has had visitors from 6 continents and 63 different countries around the world (Table 3). The highest visited website pages during this period included those that include SBAR resources (publications, presentations, and accomplishment reports) and pages that describe our team and education/outreach opportunities. Other highly visited pages included those that provide details about ongoing research. 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 – Mar 2019	Apr – Jun 2019	Jul – Sep 2019	Oct – Dec 2019
Argentina				X	
Australia	X	X	X	X	X
Austria	X			X	X
Bangladesh				X	X
Belgium					X
Brazil		X		X	X
Canada	X	X	X	X	
Chile			X		
China	X	X	X	X	X
Colombia					X
Congo-Kinshasa					X
Côte d'Ivoire				X	
Cyprus					X

Country	Time Period				
	Jul – Dec 2018	Jan – Mar 2019	Apr – Jun 2019	Jul – Sep 2019	Oct – Dec 2019
Egypt	X				
Estonia		X			
Ethiopia	X				
France		X	X		X
Germany	X		X	X	X
Ghana			X		
Honduras					X
Hong Kong	X		X	X	X
India	X	X	X	X	X
Indonesia				X	
Iran	X	X	X	X	X
Ireland			X		
Israel		X			X
Italy	X	X	X	X	X
Japan	X	X	X	X	
Kenya					X
Kuwait	X	X			
Lebanon			X		
Malaysia		X	X		
Mexico	X	X	X	X	X
Morocco			X		
Namibia			X		
Nepal	X		X		
Netherlands				X	X
New Zealand	X				
Nigeria					X
Pakistan	X		X	X	X
Paraguay					X
Peru					X
Philippines	X		X		X
Poland		X			X
Portugal					X
Qatar					X
Russia			X	X	
Saudi Arabia				X	
Singapore				X	
South Africa		X			
South Korea			X		
Spain			X	X	X
Sri Lanka			X		
Sweden			X		
Taiwan					X
Thailand	X		X		X
Turkey	X	X			
Ukraine			X		

Country	Time Period				
	Jul – Dec 2018	Jan – Mar 2019	Apr – Jun 2019	Jul – Sep 2019	Oct – Dec 2019
United Arab Emirates			X		
United Kingdom	X	X	X	X	X
United States	X	X	X	X	X
Vietnam				X	
Zambia		X			
Total	22	20	31	25	33

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:

Angadi: Guar seed yield was lower and there was a lot of variation within the trial, which masked treatment differences. The year was very unusual. The way one farmer described it, “This was a non-guar season.”

Maier/Neilson: Soil chemical analysis delayed due to the need to evaluate data generated by NMSU. Five trial soil samples were sent to 2 commercial soil labs in Phoenix and Brookside Lab in Ohio (lab used by Bridgestone). Consistent results were obtained from the three labs, but the data obtained is significantly different from that obtained originally from NMSU. Thus, we have decided not to use the NMSU soil analysis results. The 108 year 2 soils have been shipped to Brookside lab and the chemical analysis data will be presented in the year 3 Q1 report (due in April 2020). Brookside lab was selected because it is the most cost effective. Insufficient amounts of Year 1 soils remain to repeat the chemical analysis; however, select analyses can be done if specific nutrients show relevance in the year 2 soils.

Jessica Ledesma is close to completion of the soil texture analysis of the 108 soils from year 1. The delay results from the fact that we were waiting for a control soil to be analyzed by Brookside as a QC for her analyses. We now have that data and so she can complete the work. It will be completed for the next report and will be available to the Feedstock group.

Commercial chemical analysis of the Winter Dormancy soils was dependent on the results of the soil analysis trials at the three commercial labs mentioned above. Based on the trial analysis results, the soils have now been shipped to Brookside and the chemical data will be available for the next quarterly report.

McCloskey: The Fall 2019 experiments in the SOW for year 3 were started at MAC with herbicide applications and planting in October. Preemergence herbicides were applied and the fields were preirrigated in late-September to start the experiments. The fields were planted on October 17, 2019 and irrigated 10/18, 10/20, 10/22 and 10/25. This was followed by a very windy Friday 10/25 the following weekend accompanied by cold temperatures. At this point, preirrigation does not seem to have solved the problem of the beds cracking down the middle during drying. Ultimately, the fall 2019 plantings failed and the experiments were terminated. This will cause a delay in generating the data needed for herbicide registrations. Future

experiments at MAC will be conducted in a different field with better soil types and conditions. Hopefully, the problems with birds that caused the failure of the Eloy plantings can be solved for the spring 2020 plantings.

Ogden: Risk is that Sarocha Pradyawong had to return to Thailand but she has a VISA now and is expected to resume work in Q1 of year 3.

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	31 Aug 19
		Harvest/Analysis of first growth cycle completed	30 Apr 22
2 McMah	Perform plant transformations using all 3 constructs (AP1, SEP3, FT, LEAFY)	Confirmed transformation for invitro plants – 6 lines AP1	31 Aug 20
		Confirmed transformation for invitro plants – 6 lines SEP3	31 Aug 20
		Confirmed transformation for invitro plants – 6 lines FT	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	31 Jan 20
		Compare root growth and top growth for direct-seeded and transplant-established plants	31 May 20
		Compare root growth/top growth/water use	31 Mar 20

Evaluate Germplasm Lines (Variety Trials):

No new data was collected during this quarter. The first-year harvest and data analysis was completed in previous quarters, and seed was collected from most lines. The next harvest is scheduled for April 2020, with re-growth planned for a final harvest in 2022.

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, all transcription factors related to flowering, were identified; guayule transformation constructs for downregulation were prepared; and plant transformations performed. In 3Q19 a fifth construct was prepared, combining two of the above genes *APETALA1* and *SEPATTALA* in a single construct, called *pND6 – AP1 – SEP3 (pAS)*. In 4Q19, we focused on transformations of *LEAFY* and *pAS* constructs and on development of an improved transformation protocol.

To optimize the number of recovered calli we tested the effect of light intensity during selection. The protocol tracked calli formation from inoculated leaf strips in a test stack of six plates (petri dishes with media and leaf sections) as a function of position: 1 being the top plate and 6 being the bottom plate (Figure 1). At every event of plate/new media transfer, the number of potential calli were counted for the respective plate. 96 plates were evaluated and showed that plates with lower light intensity produced a higher number of calli (Figures 2-3). Transformations in the future will limit the light intensity in order to recover more calli per plate.

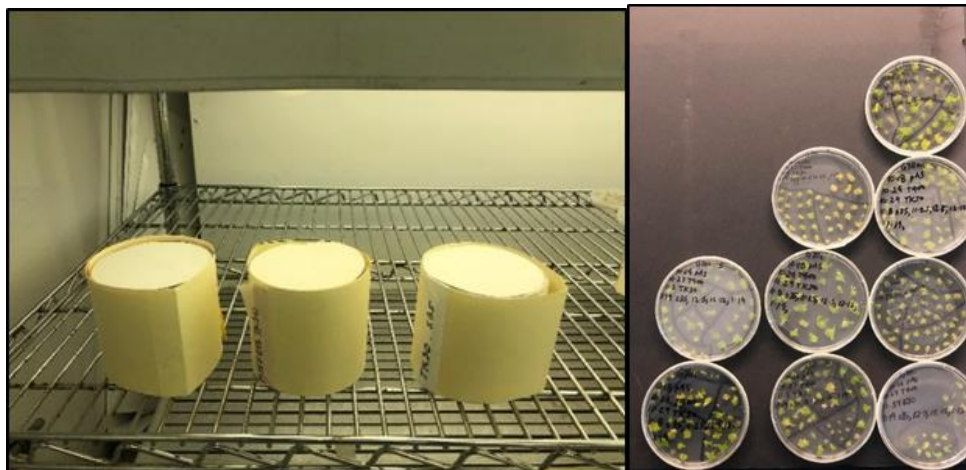


Figure 1. Process used to limit ambient light (left) and the recovered calli with the pAS construct (right). Over 60% of the calli shown in the image to the right were recovered from plates that experienced a lower light intensity.

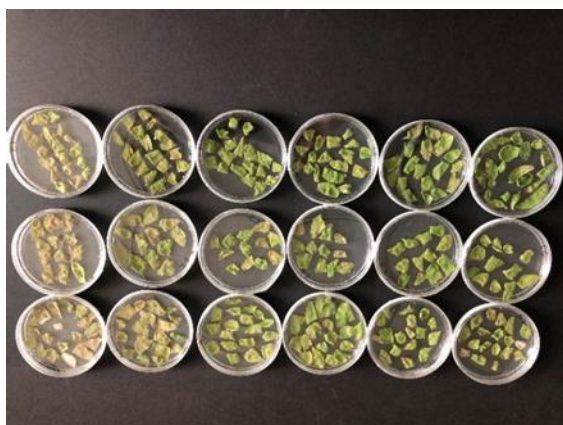


Figure 2. Guayule leaf strips showing light intensity. Effects of high light (left) to low light (right).

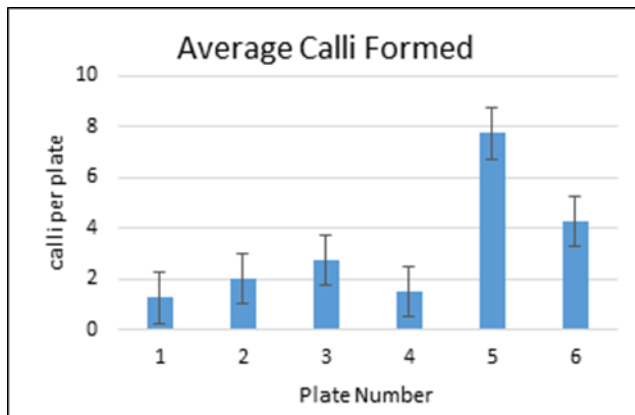


Figure 3. Average number of recovered calli per plate number.

Flowering downregulation transformations are still underway for the *pAS* construct. As of January 2020, we have 360 calli with the *pAS* construct (Figures 4-7).

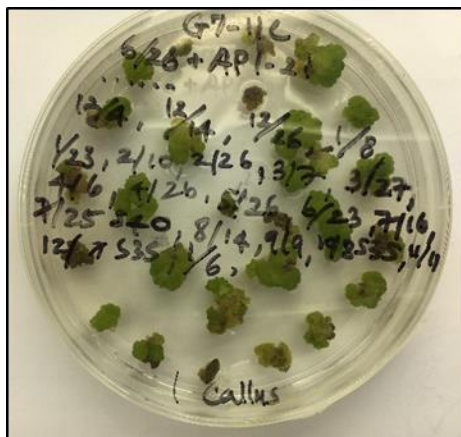


Figure 4. Calli from AP1 construct under selection.



Figure 5. Calli from FT constructs under selection.



Figure 6. Shoots recovered from guayule with downregulated *SEPATALLA* transcription factor.

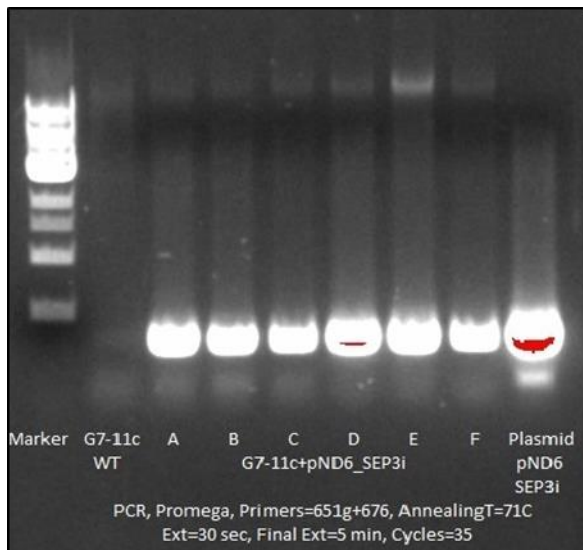


Figure 7. PCR result of the *SEP3i* transformed guayule plants A, B, C, D, E, F, as well as the non-transformed wildtype and plasmid DNA.

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:

Heights for guayule plants were measured (Table 4). Two plants from each of seven varieties were harvested, chipped and dried (Table 5), and will be analyzed for percent resin and rubber.

Table 4. Mean heights (cm) of seven guayule germplasm lines measured on 5 November 2019. Values followed by the same letter are not significantly different.

Level	Number	Mean	Std Dev	
11604	14	24.5	4.2	a
11701	14	22.2	4.5	abc
PARL803	14	18.4	3.3	d
PARL804	14	19.2	3.8	cd
PARL816	14	18.6	3.9	d
PARL914	14	19.9	3.5	bcd
R1044	14	22.6	5.0	ab

Table 5. Mean weights of seven guayule varieties harvested on 5 November 2019. Values followed by the same letter are not significantly different.

A. FRESH WT (g)					B. CHIPPED DRY WT (g)				
Level	Number	Mean	Std Dev		Level	Number	Mean	Std Dev	
11604	7	256.9	76.4	a	11604	7	60.7	31.9	a
11701	7	228.9	78.0	ab	11701	7	59.2	25.0	a
PARL803	7	192.3	91.1	ab	PARL803	7	54.2	31.8	a
PARL804	7	245.3	103.1	ab	PARL804	7	72.9	30.0	a
PARL816	7	164.7	43.6	b	PARL816	7	51.4	22.0	a
PARL914	7	223.9	70.3	ab	PARL914	7	60.5	17.6	a
R1044	7	250.4	99.6	ab	R1044	7	62.1	37.2	a

Root Growth/Architecture Compared to Water Use in Direct Seed and Transplant-Established:
Guayule plant roots were harvested on 5 October 2019 (150 DAP), 9 November 2019 (185 DAP), and 20 December (226 DAP). (Tables 6-7)

Table 6. Mean above-ground guayule biomass (ABG) and root weights by depth (g) measured at 150, 185, and 226 days after planting. Values in a column marked with * are significantly different.

	AGB (g)		Total Root Wt (g)		Plant Height (cm)	
	MEAN	SD	MEAN	SD	MEAN	SD
150 DAP						
Direct seeded (n=4)	20.5	5.9	15.0	3.3	25.8	3.3
Transplanted (n=4)	23.7	4.8	16.5	3.9	24.5	2.4
185 DAP						
Direct seeded (n=4)	22.5	3.7	19.9	1.8	25.0	3.2
Transplanted (n=4)	23.7	4.8	27.4*	5.3	24.8	2.8
226 DAP						
Direct seeded (n=4)	27.2	6.2	22.6	4.9	26.1	2.3
Transplanted (n=4)	27.2	6.6	22.0	2.4	24.8	1.3

Table 7. Mean values for "resin" (acetone-extractables) are "rubber" (cyclohexane-extractables) in guayule plant material harvested at 150 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
150 DAP								
Direct seeded (n=4)	4.89	1.09	4.06	1.01	1.75	0.61	1.01	0.06
Transplanted (n=4)	5.53	2.06	4.23	1.77	2.43	1.07	1.40*	0.12

Other Tasks:

Dormancy in guayule:

In our Dormancy collaborative study (with Julie Neilson, Omar Holguin, and Diaa El-Shikha/Pete Waller) we continued characterization of plant tissues from irrigation field trials in Maricopa before, during, and after winter dormancy. A meeting was held Dec 10, 2019: Discussion of Microbial Data: McMahan and Neilson Group Meeting, to review the new soil analysis data, and to prepare publication plans.

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

The 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 interval based on the weather and plant growth stage. Since guayule is dormant during winter, morphological and remote sensing data will be collected from 2 years plants during spring and summer. (Figure 8)

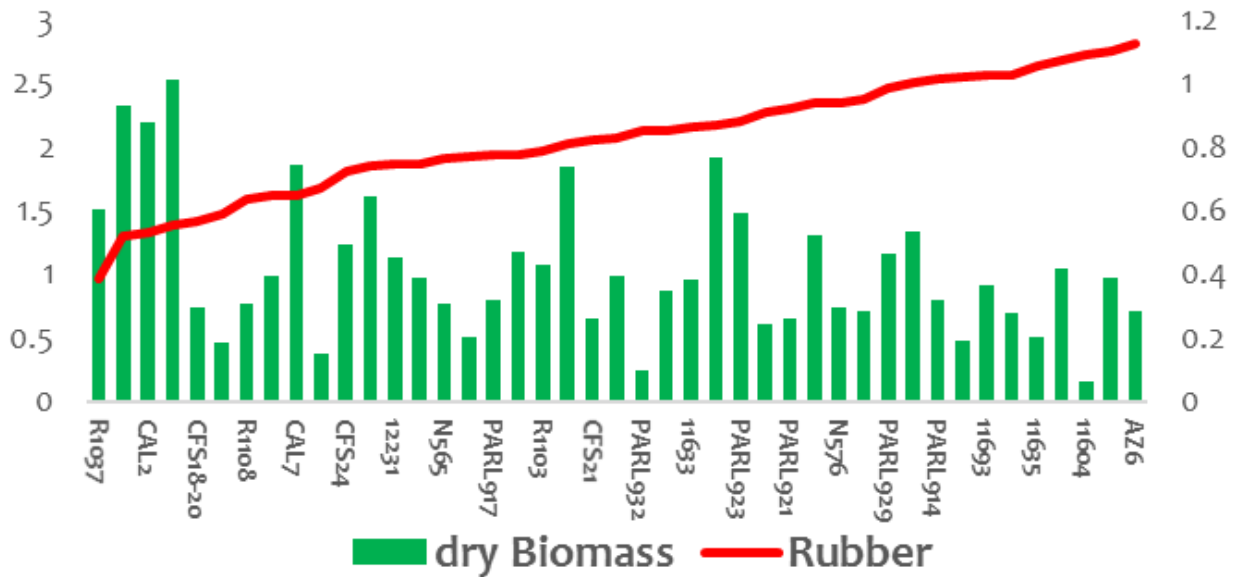


Figure 8. Rubber (left axis) and % resin (right axis) in one-year old guayule plants.

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 none stress conditions. Genotypes were transplanted into the field in October 2019, in two trials (stress and no stress treatments will start at spring) in augmented design. At both trials, plots are maintained by hand, weeding as needed, and surface irrigation at bi-weekly interval based on the weather and plant growth stage.

Guayule Leaf Waxes:

Plans to collect and extract waxes components from guayule genotypes growing under stress and non-stress will start in the coming summer. Research is continuing as planned; no new data to report.

Guar Remote Sensing:

In general, 2019 field season was not great for guar and many other crops in the region. Guar planting area and fraction of it harvested was also very low. Although, we conducted all our field trials successfully, seed yields are low and treatment variations are masked. Most of the trials will be repeated to get one more year data.

Dr. Diaa El-Shikha and Hadiqa Maqsood are working on processing the remote sensing data. The data from the deficit irrigation trial at Clovis was collected three times during 2019. We collected essential ground data during the remote sensing data collection.

Remote Sensing Evaluation of USDA Guayule Germplasm Lines:

Research is continuing as planned; no new data to report.

Objective 3. Deploy superior genotypes of guar 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 Summarize data after harvest; present at field day in Clovis, NM Assess available guar cultivars at Clovis, NM	30 Apr 20 31 Dec 19 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 Generate report on guar germplasm line field performance	31 Aug 20 31 Aug 20
4 Ray	Evaluate seed from plants surviving root rot inoculation Determine root rot tolerance per guar germplasm	Screen 42 guar germplasm lines for root rot fungus tolerance New germplasm lines screened for the first time Seed from surviving plants screened for trait inheritance	31 Jan 20 30 Nov 20 31 Dec 21
5 Ray	Guar salt tolerance trials	7 germplasm line's transplants evaluated for sensitivity under 11 saline treatments Initial estimate of lines with most tolerance complete Continue screening germplasm lines Seed from surviving plants collected and planted for 2 nd round evaluation	31 Dec 19 31 Dec 19 31 Aug 20 31 Oct 20
6 Ray	Guar yield trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM	Increase guar seed for yield tests Yield trial protocols established (3 different for comparison) Yield trials planted in 3 locations	15 Apr 19 1 May 19 30 Jun 20

		Yield trials harvested; yields compared	31 Dec 20
7 Ray	Guar genetic combination trials	Guar seed from crosses of partial male-sterile plants with 2 elite lines collected	31 Dec 19
		Genetic diversity evaluated	31 Jan 21

Guar Germplasm in New Mexico:

We harvested USDA guar germplasm study that Dr. Dennis Ray is leading. Yield levels are low. Some varieties had leaf disease issues and did not perform well. The trial showed variation in plant architecture, growth, leaf diseases and yield. The trial will be repeated during 2020 season.

Guar Galactomannan Assay:

No new activity to report.

Guar Germplasm Line Multiplication:

Guar germplasm seeds have been collected from the previous year's plantings, and evaluation of agronomic management continues.

Seed Evaluation following Root Inoculation and Root Inoculation per Guayule Germplasm:

Research continues as planned; no new activity to report.

Guayule Salt Tolerance Trials:

The initial estimates of lines with the most tolerance is complete. Results will inform the next phase of research in this task. Plants were harvested in October (Photo 2). No new data was collected this quarter; nothing new to report.



Photo 2. *Guayule harvest, October 2019.*

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

Guar pods were harvested 16-18 December (Photo 3). Primary threshing is complete (Photo 4); yields are still to be determined.



Photo 3. Guar harvest, December 2019.



Photo 4. Threshing guar plants following harvest, December 2019.

Guar Genetic Combination Trials:

Research is continuing as planned; no new data to report.

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	15 May 20
		Present data at regional and national conferences	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	31 Dec 20
		Summarize plant growth, yield performance, and traits for density trial with 2 varieties and 5 densities in Eloy, AZ	30 Apr 22

		Final harvest and analysis completed for 5 plant densities and 2 varieties in Eloy	30 Apr 20
4 Dierig	Bi-monthly harvest from irrigation trials	Growth data over seasons from two locations	31 May 20
		Harvest plots for shrub dry biomass rubber/resin content and yield	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	31 Aug 20
		Generate report/publication from results obtained	31 Aug 20
		Present research results at regional/national conferences	31 Aug 20
7 Grover	Evaluate guar response to planting density	Track and collect research data on guar density experiment	31 Aug 20
		Generate report/publication from results obtained	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 chemical weed control from seeding to 6mo old plants	28 Feb 20
		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	30 Jun 20
		Generate research report/publication and Extension bulletin from results obtained	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	15 Jul 20
		Provide data set that can be used to refine the use of sensors for WINDS crop irrigation mgmt.	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	15 Jul 20
		Database available to economic modelers	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	15 Jul 20
		Document effects of irrigation treatment on plant growth, soil moisture, plant stress, plant chemical response, plant vegetative indices, and crop coefficient	15 Jul 20
		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:

Frequent rain affected second year of deficit irrigation study. We harvested the trial and threshed all harvest samples. Yield component observation is also complete. Graduate student is working on interpreting the data and will write reports on seed yield and yield components in response to pre-season and critical stage based irrigation management. Neutron probe data, irrigation, rainfall will be used to write second chapter on water extraction patterns and water use efficiency of guar. Some of the data on soil moisture and seed yield will be shared with Hadiqa for her research work.

Incubator Study to Understand Temperature and Germination Relationships:

The data from the incubator study, which focused on assessing genetic variation among guar cultivars for temperature and crop establishment relationships, was analyzed and interpreted. (Photo 5; Figure 9) Graduate student wrote a manuscript on it for journal submission. After incorporating suggestions from all co-authors, the manuscript will be submitted to a journal. The data was also presented in Tri-society conference in San Antonio, TX.



Photo 5. Graduate student, Paramveer Singh, processing guar seedlings in the lab, Clovis, New Mexico.

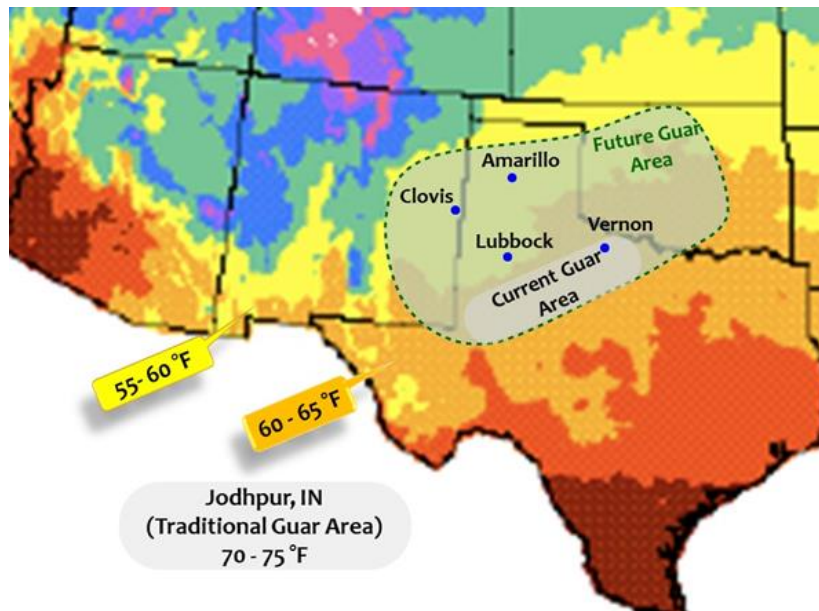


Figure 9. Potential guar area expansion by identifying cold tolerance germplasm.

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, and 5. Plots were harvested for year 1.5 at Eloy and year 1 at Tucson in October. Data for Tucson are found in other sections of this report.

The biomass of AZ-2 was significantly higher than from Sel-1 at all densities (Figure 10). Densities of 18-inch spaces and closer all had the same biomass production for AZ-2 at 18 months. Sel-1 showed no significant differences at any of the densities. However, the closer densities (6 and 3-inch spacings) were not achieved with Sel-1 so it is unclear if we would detect higher production at those densities.

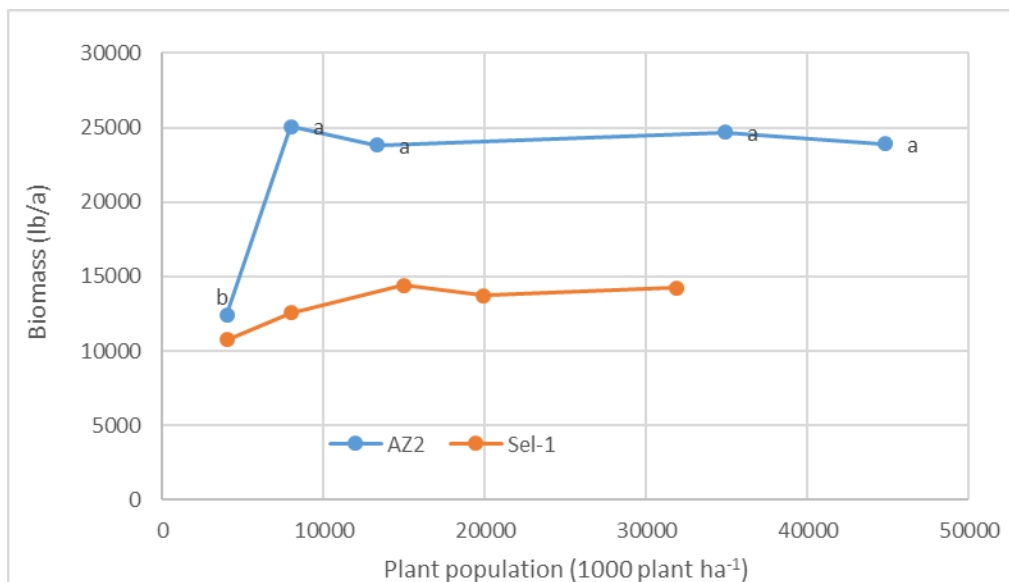


Figure 10. Biomass of plots at 5 different densities between 2 guayule varieties at 18 months old.

Rubber content (Figure 11) was not affected by densities at this age in either variety. A slight increase was seen at the 30,000 plants per ha in Sel-1 but is not significant.

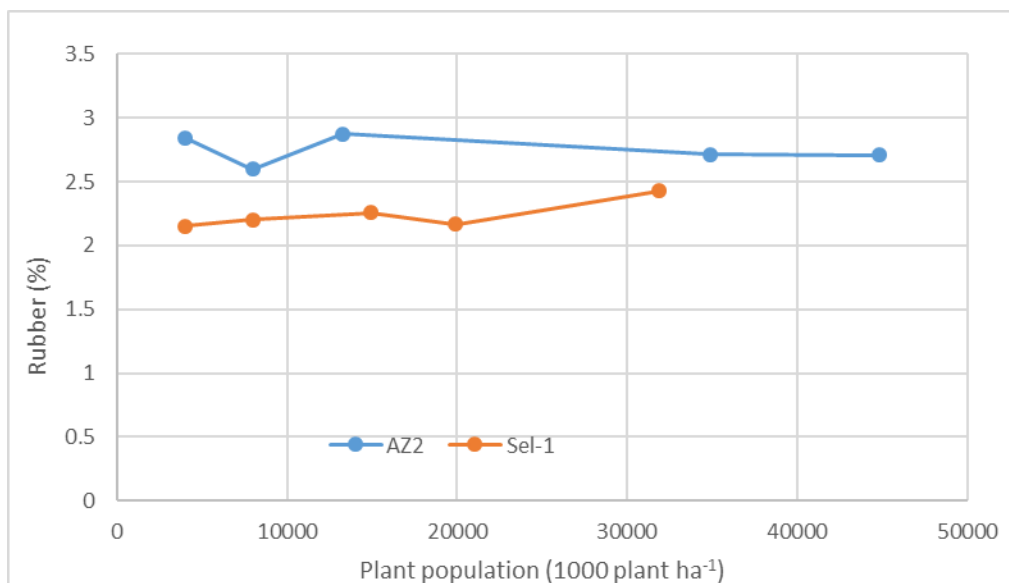


Figure 11. Rubber content of plots at 5 different densities between 2 guayule varieties at 18 months old.

Rubber yield (Figure 12) in AZ-2 was similar to its biomass yield where the 18-inch spacing and closer had no significant differences between densities. Sel-1 rubber yield had a more linear increase between densities due to the slight increase in rubber content. Overall rubber yield was higher in AZ-2 compared to Sel-1 but it is still premature to say that a low biomass/ high rubber % variety could be a more efficient choice.



Figure 12. Rubber yield of plots at 5 different densities between 2 guayule varieties at 18 months old.

Resin content (Figure 13) was unaffected by densities for either variety. AZ-2 had higher resin content than Sel-1.

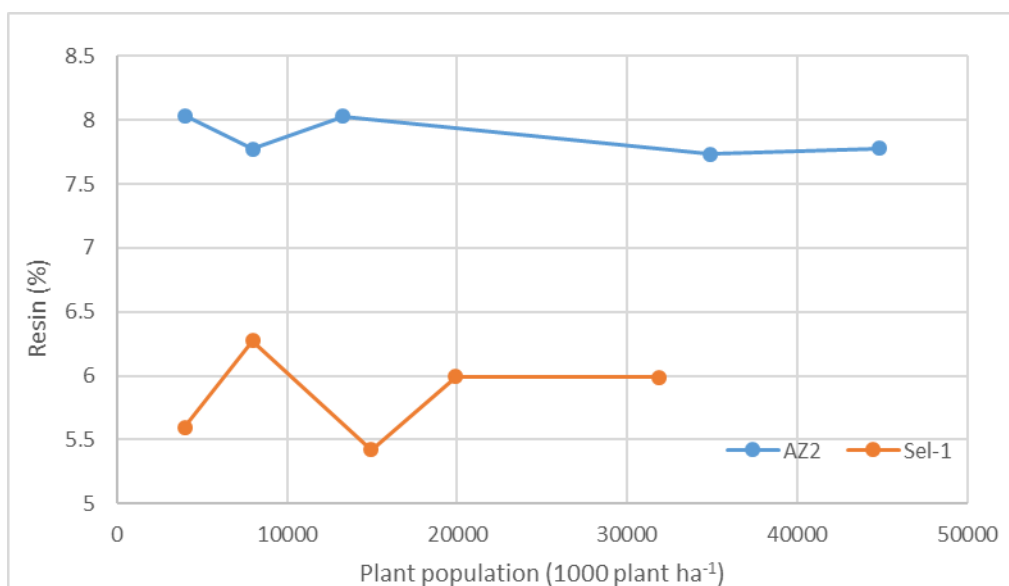


Figure 13. Resin content of plots at 5 different densities between 2 guayule varieties at 18 months old.

Bi-Monthly Harvest from Irrigation Trials:

The fields at Eloy and Maricopa were too wet due to rains during December when the next harvest was to take place. The next harvest will be January 2020.

Irrigation Timing Study:

Planning for this experiment occurred this quarter. We have discussions the treatments, lines, and data collected. There will be 2 germplasm lines (AZ-2 and Sel-1) and 3 replications planted at Eloy with furrow irrigation. There are 8 row plots 250 ft long with a two-row buffer.

The general plan will be as follows:

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 year, then no irrigation.
3. Half irrigation: Irrigate every other irrigation as determined by the model.
4. Minimum irrigation: Irrigate three times a year, approximately every growth stage (May/June, September, and February).
5. Minimum Year 2: Year 1 irrigate as determined by the model, and Year 2 irrigate three times (February, May/June, and September).
6. One irrigation: One irrigation after establishment in the first year, one irrigation in year 2

Irrigation lines are currently being installed. The field was planted with a cover crop (Barley) to be harvested prior to field preparation and planting. Establishment will be with sprinklers prior to furrow irrigation.

Guar Response to Moisture Stress:

In-season field data were collected on guar growth parameters. Final plant samples were harvested at maturity for threshing and evaluating seed yields and yield attributing characters. (Photos 6-7)



Photo 6. Guar harvest, Las Cruces, New Mexico.



Photo 7. NMSU undergraduate students assisting with guar harvest, Las Cruces, New Mexico.

An abstract was published and presentation delivered at the International Annual Meetings ASA-CSSA-SSSA Tri-society, San Antonio, TX, USA.

Guar Response to Planting Densities:

Nothing new to report.

Guayule Herbicide Tolerance Study, Fall 2019:

Unfortunately, the guayule planted for these experiments at Maricopa emerged but did not establish seedlings resulting in failed plantings. Similarly, the guayule plantings in Eloy failed albeit for different reasons. Thus, the needed experiments could not be conducted. (Table 8)

Table 8. Attempted herbicide experiments, Fall 2019.

Spray Date	Chemicals Applied	Location/ Field	Method of Incorporation	ARM File Name / Data Tables?	Data Collected to Date
10-16-2019	Prowl H2O Dual Magnum Spartan Prefar	MAC / F1 / B33	PPI-flat with field cultivator, sequential PPI-bedtop with incorporvator	Prowl PPI flat fb PPI POST treatments MAC Fall 2019 F1 B33	Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned
10-16-2019	Prowl H2O Dual Magnum Spartan Prefar	MAC / F1 / B34	PPI-flat with field cultivator, sequential PPI-bedtop with incorporvator		Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned
10-16-2019	Prowl H2O AIM	MAC / F1 / B35	PPI-flat with field cultivator, sequential postemergence Aim treatments		Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned
10-16-2019	Prowl H2O AIM	MAC / F1 / B36	PPI-flat with field cultivator, sequential postemergence Aim treatments		Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned
10-16-2019	Warrant Dual Magnum	MAC / F1 / B37	PPI-bedtop incorporvator, rolling cultivator	Dual Warrant PPI-Bed Top Fall 2019 F1 B37	Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned
10-16-2019	Spartan Prefar	MAC / F1 / B38	PPI-bedtop incorporvator, rolling cultivator	Spartan PPI-BedTOP FALL 2019 F1 B38	Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned
10-16-2019	Dual Magnum Warrant Spartan Prefar	MAC / F1 / B39	PPI-flat with field cultivator, sequential PPI-bedtop with incorporvator	Dual Prefar Spartan Warrant PPI-Flat Fall 2019 MAC F1 B39	Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned
10-16-2019	Prowl H2O Sonalan	MAC / F1 / B40	PPI-flat with field cultivator, sequential PPI-bedtop with incorporvator	Prowl Sonalan PPI-Flat Fall 2019 MAC F1 B40	Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned
10-16-2019	Prowl H2O Sonalan	MAC / F1 / B41	PPI-bedtop incorporvator, rolling cultivator	Prowl Sonalan PPI-bedTop MAC FALL 2019 F1 B41	Guayule plants emerged but failed to thrive and get established; the stand was lost and the experiment was abandoned

The guayule fields planted in spring 2019 for the grass herbicides and Aim postemergence studies were used to conduct a screening study of herbicides post-directed at the soil between plant rows was initiated (Photo 8). Frequent rains in fall/winter delayed the post-directed herbicide applications until January 2020.



Photo 8. Results of application of Aim at 2 fl.oz/acre on 3.5-leaf guayule seedlings, 7 days after transplant.

Guayule Herbicide Tolerance Study, Spring 2020:

Soil samples were collected in four different fields at Maricopa to help choose the best field for the spring 2020 experiments at MAC. It was important to select a field with less sand and more silt and clay than field 1 to minimize problems in obtaining an adequate plant population for the experiments. Field 5E was chosen for the spring 2020 experiments. Planning for the spring 2020 experiments at Eloy was also initiated.

A Research Report on the 2018 Aim postemergence experiments was drafted and will be submitted to UA Cooperative Extension Manuscript Fastrack site in early 2020. A draft research report of 2019 Aim experiments is in progress.

Research technician Bryan Pastor was largely responsible for setting up the experiments, spraying the herbicide treatments, and collecting the data with some help from me. Bryan is (was) also responsible for all data entry into a database program for field research (Agricultural Research Manager; Gylling Data Management, Inc.) and for the analysis of the nadir photographs.

Development and Testing of AquaCrop Model:

We have studied the project detail and found suitable plant growth models for guayule. We have focused on 2 plant growth models: AquaCrop and BioCrop.

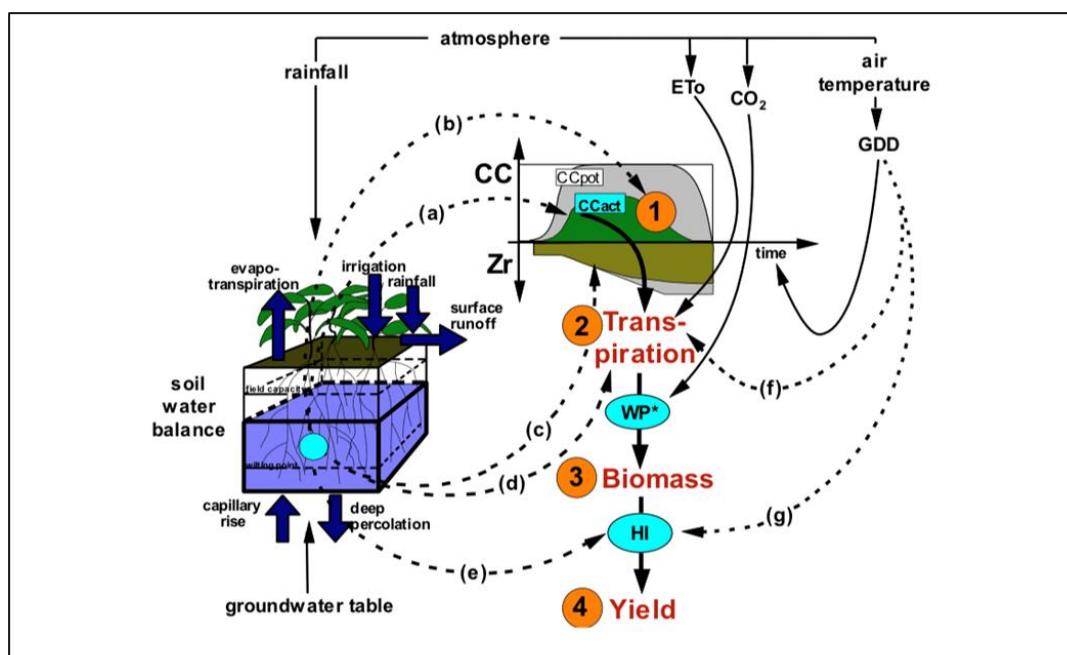


Figure 14. Diagram of various AquaCrop parameters.

AquaCrop is being used to simulate the growth cycle of guayule (Figures 14-15). The main difficulty is adapting the model to the three periods of dormancy that the plant goes through each year. Simulation output includes canopy cover (CC), Root depth, Water fluxes, Biomass, and Yield.

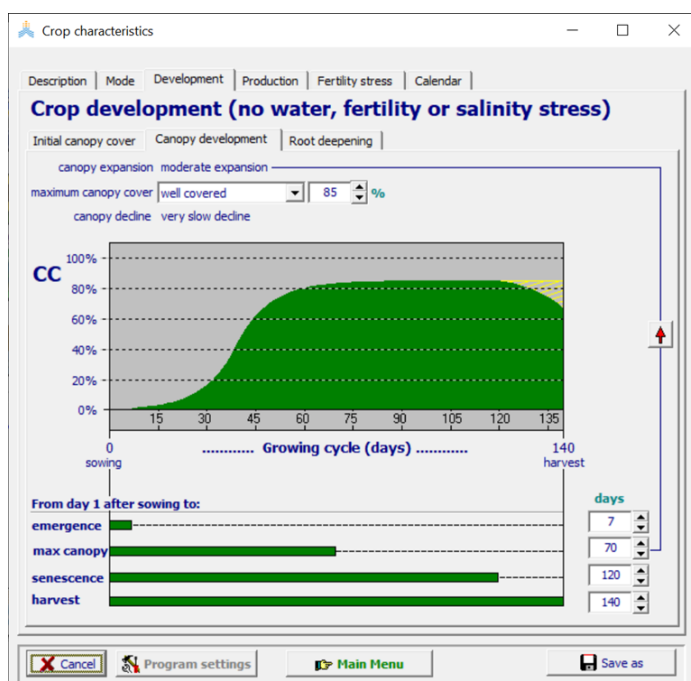


Figure 15. Screenshot capture of the AquaCrop model information generated for guayule under generic conditions.

Currently modeling data at MAC and fitting the CC data (Figure 16) – a complete weather fetch is necessary. The pre-packaged model is almost complete that will “instantly” start sensitivity analysis. New data through 2019 is currently being inputted.

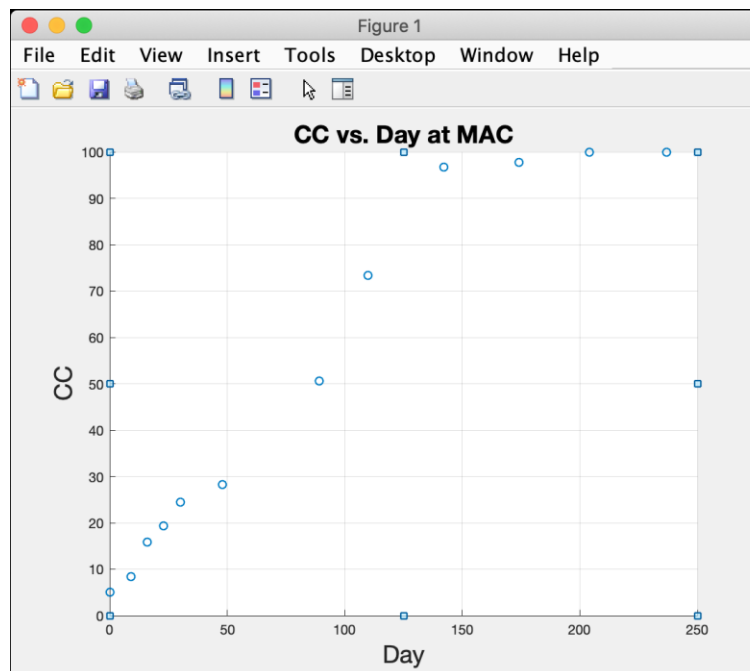


Figure 16. MAC CC data to be modeled using AquaCrop.

Modifications that will be necessary for the AquaCrop Model to work better for our needs includes:

- Model can only simulate complete periods of growth (seed/transplant to harvest)
- Possible to piece together parts of different simulations to create a complete model
- Model output would be a “piecewise” simulation around dormancy
- Variables to modify include: important time constraints (highlighted in teal; Table 9)
- Include module for automatic weather data pulling and formatting

- Create interactive user interface for running simulations with different data sets (Figure 17)

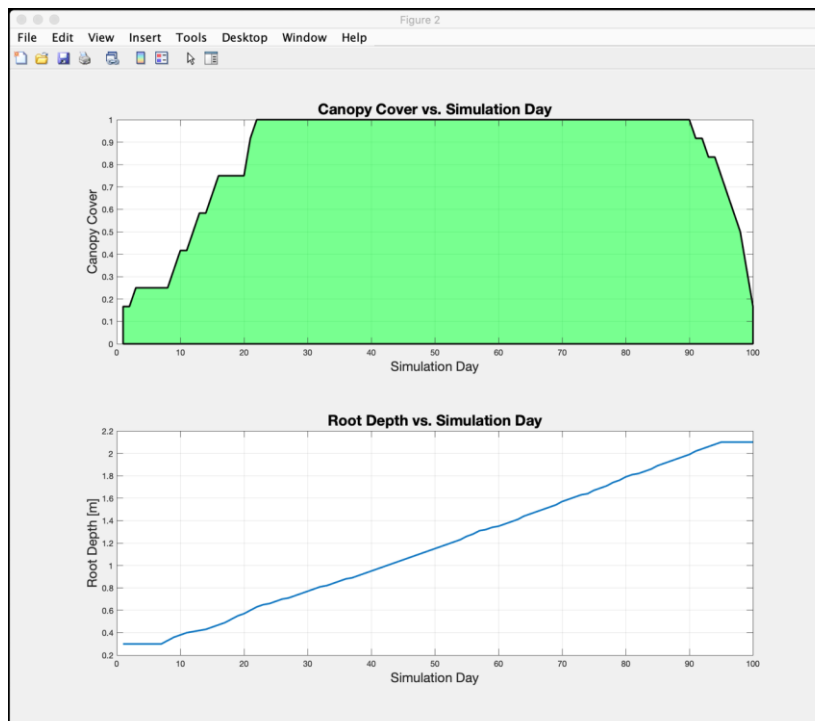


Figure 17. Example of custom MATLAB simulation option.

Data sources referenced as of Spring 2019 are provided below.

Weather Information	https://cals.arizona.edu/azmet/data/
Water Table Information	Diaa El-Shikha
Soil Texture	Diaa El-Shikha
Soil Profile	Diaa El-Shikha
Soil Hydrology	Pete Waller, Doug Hunsaker
Soil Mechanics	Doug Hunsaker
CO2 Data	www.esrl.noaa.gov/gmd/ccgg/trends/
Irrigation Schedule	Diaa El-Shikha
Irrigation Management	Doug Hunsaker
Water Content	Doug Hunsaker
Field Management	Doug Hunsaker
Crop Rotation	Pete Waller
Crop Mix	Pete Waller
Crop	Pete Waller

Table 9. AquaCrop Model data sources referenced as of Spring 2019.

Parameter	Value	Comments	Source
Planting date	April 2018		
Harvest date	April 2020		
Emergence	80	Use the first month data, from Diaa use the data till May 23, 2019----- from Doug use the data from the first day to 7 to 12 weeks)	Doug Hunsaker
Maxrooting	1400	(use April to Aug about 5 months for this time growth)	Doug Hunsaker
Senescence	1400	Growing degree/Calendar days from sowing to senescence	
Maturity	1700	Use till full cover... 1 year for transplant..... Diaa about a year data recheck with the data to 100 percent coverage use till the Jan the 2, 2019)	Doug Hunsaker
Histart	880	Growing degree/Calendar days from sowing to start of yield formation	Doug Hunsaker
Flowering	-999	Duration of flowering in growing degree/calendar days (-999 for non-fruit/grain crops)	Doug Hunsaker
Yldform	750	Duration of yield formation in growing degree/calendar days	Doug Hunsaker
Tbase	10	Base temperature (degc) below which growth does not progress	Dennis Ray
Tupp	37.78	Upper temperature (degc) above which crop development no longer increases	Dennis Ray
Polheatstress	1 or 0	Pollination affected by heat stress (0: No; 1: Yes)	Dennis Ray
Tmax_up	32.22	Maximum air temperature (degc) above which pollination begins to fail(32.22-37.78)	Dennis Ray
Tmax_lo	43.33	Maximum air temperature (degc) at which pollination completely fails	Dennis Ray
Polcoldstress	0 or 1	Pollination affected by cold stress (0: No; 1: Yes)	Dennis Ray
Tmin_up	10	Minimum air temperature (degc) below which pollination begins to fail	Dennis Ray
Tmin_lo	10	Minimum air temperature (degc) at which pollination completely fails	Dennis Ray
Biotempstress	1	Biomass production affected by temperature stress (0: No; 1: Yes)	Pete Waller

GDD_up	0 to	Minimum growing degree days (degc/day) required for full biomass production	Doug Hunsaker
GDD_lo	-2.5 or 12.5	Growing degree days (degc/day) at which no biomass production occurs	Doug Hunsaker
Fshape_b	13.8135	Shape factor describing the reduction in biomass production for insufficient growing degree days	Pete Waller
Pctzmin	70 to 75	Initial percentage of minimum effective rooting depth	Doug Hunsaker
Zmin	0.3	Minimum effective rooting depth (m)	Doug Hunsaker
Zmax	2.1	Maximum rooting depth (m)	Doug Hunsaker
Fshape_r	1.3	Shape factor describing root expansion	Doug Hunsaker
Fshape_ex	-6	Shape factor describing the effects of water stress on root expansion	Doug Hunsaker
Sxtopq	0.0104	Maximum root water extraction at top of the root zone (m3/m3/day)	Pete Waller
Sxbotq	0.0026	Maximum root water extraction at the bottom of the root zone (m3/m3/day)	Pete Waller
A_Tr	1	Exponent parameter for adjustment of Kcx once senescence is triggered	Doug Hunsaker
Seedsize	6.5	Soil surface area (cm2) covered by an individual seedling at 90% emergence	Doug Hunsaker
Plantpop	48000	Number of plants per hectare	Doug Hunsaker
Ccmin	0.1	Minimum canopy size below which yield formation cannot occur	Doug Hunsaker
Ccx	1	Maximum canopy cover (fraction of soil cover)	Doug Hunsaker
Cdc	0.01	Canopy decline coefficient (fraction per gdd)	Doug Hunsaker
Cgc	0.0125	Canopy growth coefficient (fraction per gdd)	Pete Waller
Kcb	1.3	Crop coefficient when canopy growth is complete but prior to senescence	Doug Hunsaker
Fage	0	Decline of crop coefficient due to ageing (%/day) %%	Doug Hunsaker
Wp	33.7	Water productivity normalized for et0 and c02 (g/m2)	Sarocho Pradyawong
Wpy	100	Adjustment of water productivity in yield formation stage (% of WP)	Sarocho Pradyawong
Fsink	0.2	Crop co2 sink strength coefficient	Sarocho Pradyawong
Bsted	0.000138	Wp co2 adjustment parameter given by steduto et al. 2007	Sarocho Pradyawong

Bface	0.001165	Wp co2 adjustment parameter given by face experiments	Sarocho Pradyawong
Hi0	0.06 to 0.07	Reference harvest index	Doug Hunsaker
Hiini	0.01	Initial harvest index	Doug Hunsaker
Dhi_pre	0	Possible increase of harvest index due to water stress before flowering	Doug Hunsaker
A_HI	0	Coefficient describing positive impact on harvest index of restricted vegetative growth during yield formation	Pete Waller
B_HI	0	Coefficient describing negative impact on harvest index of stomatal closure during yield formation	Pete Waller
Dhi0	0	Maximum allowable increase of harvest index above reference	Pete Waller
Determinant	1	Crop Determinancy ('0': Indeterminant, '1': Determinant)	Pete Waller
Exc	0	Excess of potential fruit	Pete Waller
Maxflowpct	33.33	Percentage of total flowering at which peak flowering occurs	Doug Hunsaker
P_up1	0	Upper soil water depletion threshold for water stress effects on affect canopy expansion	Doug Hunsaker
P_up2	0.69	Upper soil water depletion threshold for water stress effects on canopy stomatal control	Doug Hunsaker
P_up3	0.95-1	Upper soil water depletion threshold for water stress effects on canopy senescence	Doug Hunsaker
P_up4	0.8	Upper soil water depletion threshold for water stress effects on canopy pollination	Doug Hunsaker
P_lo1	0.1	Lower soil water depletion threshold for water stress effects on canopy expansion	Doug Hunsaker
P_lo2	0.1	Lower soil water depletion threshold for water stress effects on canopy stomatal control	Doug Hunsaker
P_lo3	0.1	Lower soil water depletion threshold for water stress effects on canopy senescence	Doug Hunsaker
P_lo4	0.1	Lower soil water depletion threshold for water stress effects on canopy pollination	Doug Hunsaker
Fshape_w1	2.9	Shape factor describing water stress effects on canopy expansion	Doug Hunsaker
Fshape_w2	6	Shape factor describing water stress effects on stomatal control	Doug Hunsaker
Fshape_w3	2.7	Shape factor describing water stress effects on canopy senescence	Doug Hunsaker

Fshape_w4	1	Shape factor describing water stress effects on pollination	Doug Hunsaker
Etadj	0	Adjustment to water stress thresholds depending on daily ET0 (0: 'No', 1: 'Yes')	Doug Hunsaker
Aer	5	Vol (%) below saturation at which stress begins to occur due to deficient aeration	Doug Hunsaker
LagAer	3	Number of days lag before aeration stress affects crop growth	Doug Hunsaker
Beta	12	Reduction (%) to p_lo3 when early canopy senescence is triggered	Pete Waller
Germthr	0.4-0.5	Proportion of total water storage needed for crop to germinate	Doug Hunsaker

Development of BioCrop Model:

This is on hold at this time as S. Pradyawong is on leave.

Guayule Density Trials (Direct-Seeded and Transplant-Established):

Plant heights were measured on 4 October (Table 10), where treatments are defined as:

- 1 = 1 plant every 30" (76.2 cm)
- 2 = 1 plant every 18" (45.7 cm)
- 3 = 1 plant every 12" (30.5 cm)
- 4 = 1 plant every 6" (15.2 cm)
- 5 = 1 plant every 3" (7.6 cm)

Table 10. Guayule plant heights. Values followed by the same letter are not significantly different.

Overall:

Level	Number	Mean	Std Dev	
1	40	71.7	15.0	ab
2	40	71.6	13.2	ab
3	40	74.6	13.9	a
4	40	70.2	12.1	ab
5	40	68.4	12.9	b

By variety:

AZ2

Level	Number	Mean	Std Dev	
1	20	85.3	5.9	a
2	20	83.8	4.7	ab
3	20	86.9	8.1	a
4	20	80.7	4.2	bc
5	20	80.1	5.5	c

Sel1

Level	Number	Mean	Std Dev	
1	20	58.2	6.4	b
2	20	59.4	4.5	ab
3	20	62.3	3.5	a
4	20	59.8	7.4	ab
5	20	56.7	4.9	b

Two plants from each plot were harvested on 9 October. Samples were analyzed for percent resin and rubber. Biomass, resin, and rubber yields were calculated and are presented in Table 11. Densities are defined as:

Density_1 = 1 plant every 30" (76.2 cm)

Density_2 = 1 plant every 18" (45.7 cm)

Density_3 = 1 plant every 12" (30.5 cm)

Density_4 = 1 plant every 6" (15.2 cm)

Density_5 = 1 plant every 3" (7.6 cm)

Table 11. Guayule density trial harvest results. A. Biomass yield; B. Percent resin; C. Resin yield; D. Percent rubber; E. Rubber yield. Values for a variety in a column followed by the same letter are not significantly different. Values for a parameter followed by * are significantly different by variety.

A.BIOMASS YIELD

	AZ2				SEL1			
Level	N	Mean	Std Dev		N	Mean	Std Dev	
Density_1	4	14115.4	500.0	A*	4	5085.2	1793.3	B
Density_2	4	12689.9	1708.9	A*	4	7739.6	1021.9	AB

Density_3	4	11142.3	2919.2	A	4	9284.2	2737.4	A
Density_4	4	13842.9	3994.4	A	4	8917.4	831.9	A
Density_5	4	13468.5	4115.6	A	4	9496.9	1994.6	A

B.PERCENT RESIN

	AZ2				SEL1			
Level	N	Mean	Std Dev		N	Mean	Std Dev	
Density_1	4	6.2	0.2	A*	4	4.8	0.9	A
Density_2	4	6.3	0.5	A*	4	4.4	0.4	A
Density_3	4	6.1	0.3	A*	4	4.6	0.3	A
Density_4	4	6.5	0.8	A*	4	4.6	0.7	A
Density_5	4	6.6	0.3	A*	4	5.1	0.4	A

C.RESIN YIELD

	AZ2				SEL1			
Level	N	Mean	Std Dev		N	Mean	Std Dev	
Density_1	4	876.8	8.2	A*	4	239.5	83.1	C
Density_2	4	799.8	62.3	A*	4	340.6	41.6	BC
Density_3	4	674.3	170.5	A	4	423.8	122.4	AB
Density_4	4	884.1	195.6	A*	4	412.7	61.3	AB
Density_5	4	883.6	260.7	A*	4	491.6	132.2	A

D. PERCENT RUBBER

AZ2					SEL1			
Level	N	Mean	Std Dev		N	Mean	Std Dev	
Density_1	4	1.6	0.1	AB*	4	1.2	0.2	AB
Density_2	4	1.7	0.2	AB*	4	1.1	0.1	B
Density_3	4	1.4	0.1	B	4	1.1	0.2	AB
Density_4	4	1.7	0.3	A*	4	1.1	0.3	B
Density_5	4	1.7	0.1	A*	4	1.4	0.2	A

E. RUBBER YIELD

AZ2					SEL1			
Level	N	Mean	Std Dev		N	Mean	Std Dev	
Density_1	4	231.7	9.7	A*	4	56.8	16.9	C
Density_2	4	208.9	26.6	AB*	4	86.4	14.0	BC
Density_3	4	156.2	49.0	B	4	104.1	27.7	AB
Density_4	4	223.1	38.5	AB*	4	94.2	27.0	BC
Density_5	4	231.9	72.8	A	4	137.7	40.5	A

Range of N and P Application:

Guayule germplasm (AZ2) seedlings are being grown in trays. Delivery pumps (for N and P) are being installed.

Installation of TDR, Infrared Cameras, and Flowmeter System:

Construction has started on the new TDR and camera sensors. Design and construction of flowmeter sensors has not yet started.

Matt Katterman is constructing the new TDR and thermal camera sensors to be used in the new irrigation experiment at Eloy. He also continued to collect the neutron probe readings each week.

Python MySQL WINDS Model Integration with Existing Tools:

We are continuing the development of WINDS model. We decided to use PIX4D for image processing, and it is working very well.



Photo 9. Guayule research plot used for irrigation experiments, Maricopa Agricultural Center, Maricopa, Arizona.

Hadiqa Maqsood has processed the first and second year guar irrigation data and continues to refine the WINDS model for the guar experiments. She also developed remote sensing NDVI, 3D, and visual images of the guar experiment with the images collected in drone flights conducted by Diaa El-Shikha. She is developing algorithms for calculating the evaporation rate in the early season and the transpiration rate in the midseason based on neutron probe, irrigation, and precipitation data. Matt Katterman is beginning the WINDS analysis of the

guayule experiments. Danielle Murdoch-Hoare is continuing to work on the WINDS website and linking the database, model, and sensors.

Irrigation Experiments – Guayule and Guar:

The irrigation experiments are continuing as scheduled. No new information to report.

Deficit irrigation study (water stress):

Research plans are finalized; we are on schedule to begin this experiment.

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, NO ₃ -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
			1 Feb 20

		Amplicon sequencing of bacteria, archaea, and fungi 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 Collect temperature data DNA extraction for 215 samples Amplicon sequencing: bacteria, archaea, fungi Generate microbial community profiles and network analysis	1 May 20 1 May 20 30 Jun 20 1 Aug 20 1 Oct 20

Chemical and Physical Analysis:

Five soils were sent to three commercial labs. Brookside in Ohio was selected for analysis. Year 2 soils have been sent for analysis. Soil texture analysis is in process.

DNA Extraction for Microbiome Analysis:

Extractions are complete for the 108 samples collected in 2018 and in progress for the 2019 samples. Amplicon sequencing is complete for Year 1 Eloy samples. Bioinformatics analysis is in progress to determine microbial community metrics for bacteria, archaea, and fungi.

Soil sampling for guayule-microbe irrigation study:

Planning will be in collaboration with Diaa El-Shikha and Dave Dierig to determine harvest data for irrigation trial. Soil sampling will be done within 24-hours of harvest.

Winter Dormancy Rubber Production Study:

Significant progress was made during Q4 for Task 2d of the Winter Dormancy Study. Three sampling dates were evaluated that correspond to three important guayule growth stages of induction of rubber biosynthesis, winter dormancy with active rubber biosynthesis, and spring return to rapid growth. Bacterial and archaeal alpha diversity or community richness did not change significantly for the different guayule growth stages; however, significant variation was observed in community composition or beta diversity (Figure 19).

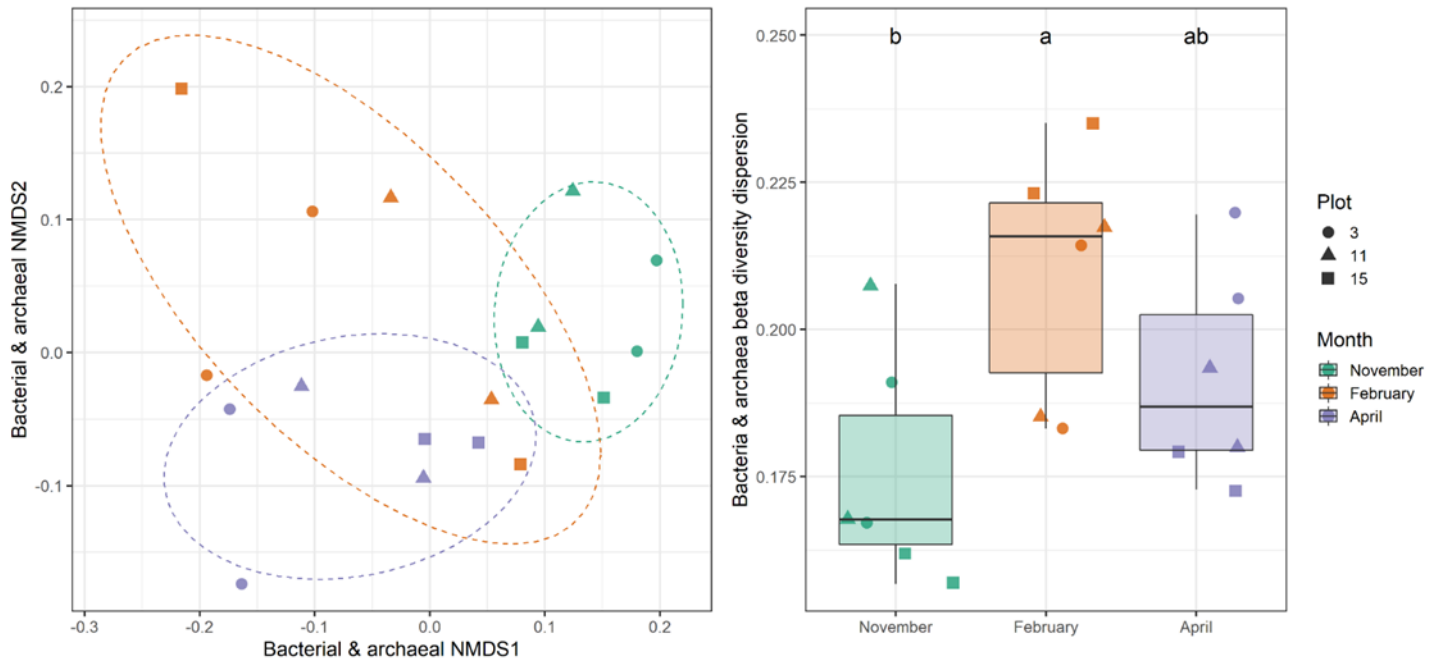


Figure 18. Variability in bacterial and archaeal community composition observed across 18 soil samples.

Significant variability in bacterial and archaeal community composition was observed across the 18 samples as seen in the ordination plot on the left. 25% of the variability is explained by sampling time (i.e., growth stage; $p < 0.001$). The month with the greatest spatial heterogeneity in community composition was February as indicated by the size of the ellipse in the ordination plot on the left and the diversity dispersion plot on the right that shows that February has significantly higher diversity dispersion than November. This pattern parallels the biomass data displayed in the Q3 report. Phylogenetic analysis shows a greater variability in the relative abundance of specific phyla in February that was not observed in November. Variable abundance was observed for Proteobacteria, Acidobacteria, Firmicutes, and Bacteroidetes.

Fungal richness did not vary significantly with growth stage; however, there was an increasing trend in average fungal richness from November to April. Fungal community composition did show temporal and spatial variation as shown in Figure 19; however, the variation in community composition was less than that observed for bacteria and archaea.

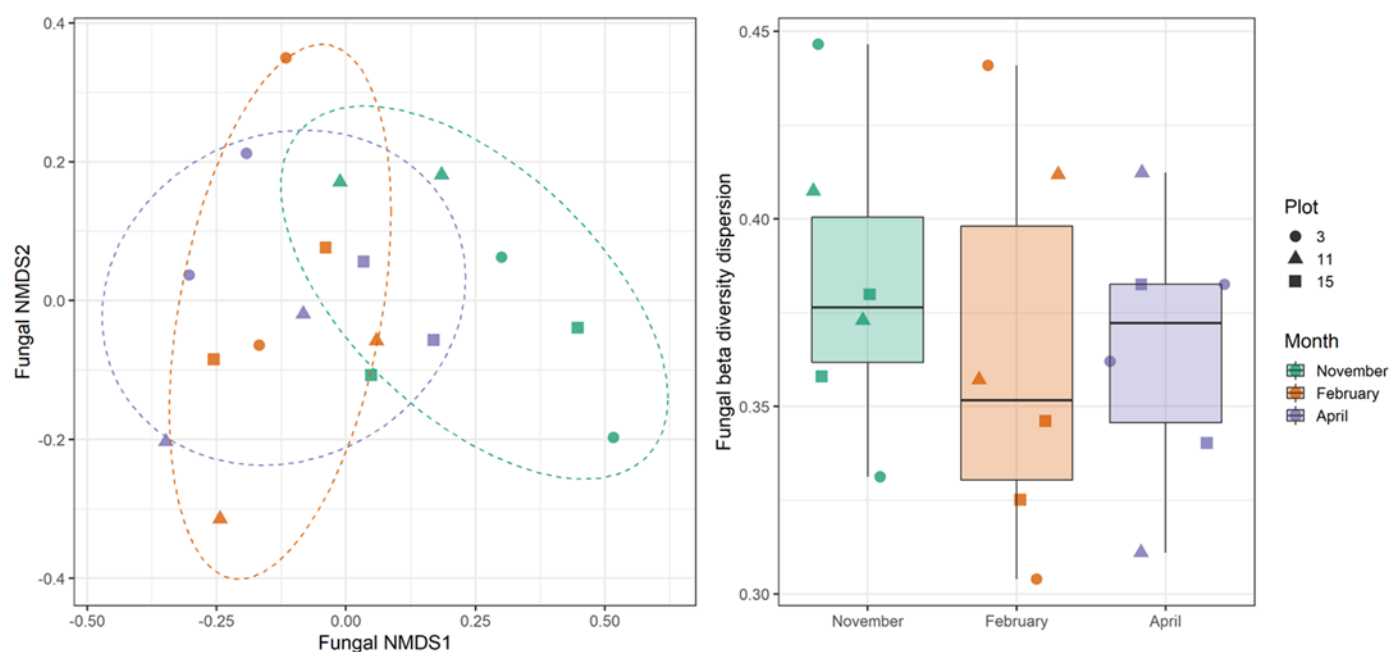


Figure 19. Variability in fungal community composition observed across 18 soil samples.

Variability in fungal community composition is demonstrated by the ordination plot on the left. Month sampled or guayule growth stage explained 20% of the variability in fungal community composition. The dispersion plot on the right shows that there was no significant difference in the spatial variability in fungal community composition for the three sample time points. In fact, spatial variability was slightly lower in February, a trend that is opposite to that observed for bacteria and archaea. Thus, a temporal change is observed in fungal community composition, but it does not appear to be associated with a specific plant or field location effect as observed for bacteria/archaea. Phylogenetic analysis of the fungal communities revealed a significant increase in Glomeromycetes class in February and April. This group includes the mycorrhizal fungi and form plant associations that increase nutrient availability for plants. The relative abundance of this class was spatially variable in February and April with the greatest abundances observed for plants 11A and 15A in February; and for 3B, 15A and 15B in April. The abundance of this group was lowest in field location 11B in February and April.

We held a conference call with the McMahan research group and decided to do a complete soil chemical analysis to facilitate an extensive correlation analysis evaluating interactions between guayule plant metrics, variation in microbial community composition, and soil chemical properties. This soil chemical data will be added to the pH, EC, $\text{NH}_4\text{-N}$, and bioavailable P data that have generated here at the UA. In addition, soil moisture data was obtained from the Diaa El-Shikha's neutron probe measurements to be included in the correlation analysis.

pH, EC, $\text{NH}_4\text{-N}$, and bioavailable P complete. Decision made with McMahan group to conduct a complete soil analysis from Brookside labs to provide additional data. Soils shipped for analysis. 72 DNA extractions have been completed for the soils collected. Bacterial quantification is complete. Data is now being processed and evaluated to determine whether fungal

quantification is relevant. Amplicon sequencing and microbial community diversity analysis is complete. Further analysis will be done when all soil chemistry data is available.

Temporal microbiome analysis of community interactions:

Sampling was completed in August, September, October, November and December at the Eloy field. Monthly sampling will continue through April 2020. Temperature data has been collected for all sampling dates. DNA extraction from soil samples will be completed when field sampling is completed in April.

POST-HARVEST LOGISTICS & CO-PRODUCTS

Project Coordination: The Logistics 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:

Gunatilaka: We were planning to do both chemical and microbial transformations of guayule metabolites. Although chemical transformations went well, microbial transformations did not proceed as anticipated. We are still continuing with this task as Mark DeDecker from Bridgestone has provided us with a new batch of resin which he thinks contains different metabolites. If we are able to obtain these in reasonable amounts, we hope to try both chemical and microbial transformations with these. Realistically, work on this will continue until the end of August 2020.

Holguin: We previously reported that a gas chromatography is our primary instrument for metabolomics work was nonfunctional. The instrument has been troubleshooted and parts are on the way. (<6-month delay) The Holguin lab laboratory manager overseeing chemical analysis has resigned. We have received approval for a replacement and anticipate having the job advertisement out late January 2020. Hiring is anticipated to be complete by the end of Q1. (<6-month delay) Lastly, funds have been late for distribution to NMSU resulting in delays for supplies and personnel. We have an institutional waiver approved which allows us to continue spending until the funds arrive. Our funds have arrived and were available in December. (<6-month delay)

Ogden: Risk is that Sarocha Pradyawong had to return to Thailand but has a VISA now. A substantial Risk is if the cooperative agreement gets signed by Bridgestone since they supply resin and will do analysis for UA.

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 2 nd 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:

We continue to perform biomass characterization methods with Dr. Brewer's group on bagasse material. Dr. Jarvis has acquired positive- & negative-ion ESI and positive-ion APPI FT-ICR mass spectra of the whole resin, the nonpolar fraction, and polar fraction of the resin. The spectra has been calibrated and chemical formulae assigned to the negative-ion ESI spectra. Dr. Jarvis is working on assigning formulae to the rest of the collected spectra. In addition approximately 30 mass spectra from the guayule and guayule/algae to process in support of Dr. Brewer research team has been collected.

We are also performing High Temperature GC-TOF MS followed by NIST library spectra matching, this has been delayed due to instrumental issues which we hope to resolve early in Q1 2020.

A draft of the publication "Natural Products in the Desert Southwest: Guayule (*Parthenium argentatum*) and Guar (*Cyamopsis tetragonolobus*)" is being finalized and formatted. This publication is ready for submission to the "Plant Management Network".



Photo 10. NMSU graduate students working with surviving guayule plants after a freeze, Las Cruces, New Mexico.

Guar Bagasse Biochemical Composition Analysis:

We have completed the enzyme analysis and size exclusion analysis for all guar samples and our now combining the results into a report. We have found a discrepancy in the values obtained on our samples from those reported in literature for gum yield using the enzymatic kit. We are consulting the manufacture as well as improving the process to get more accurate yields. Currently we have not resolved this issue and are investigating alternative methods.

We have isolated *Rhizobium* from nodules of guar plants grown at NMSU: Leyendecker Plant Science Center and Fabian Garcia Science Center and performed the sequencing.

- Genomic DNA was isolated from *Rhizobium* from both types of nodules.
- The 16S ribosomal gene was amplified from *Rhizobium* genomic DNA and sequenced.
- *Rhizobium* was identified for the determinate nodules and is being identified for the *Rhizobium* found in indeterminate nodules (Photo 11)



Photo 11. Determinate (left) and Indeterminate (right) nodules from guar plants grown in Las Cruces, New Mexico.

- Five *Rhizobia* species were identified within the guar plants grown in Fabian Garcia : *Rhizobium azibense* 23C2, *Rhizobium* sp. AC93c, *Rhizobium* sp. T1Gsb2, *Rhizobium* sp. Cap_B1, and *Rhizobium pakistanense* BN-19.

Three species of nodule associated bacteria identified: *Pseudomonas*, *Bordetella*, and *Agrobacterium*.

Analytical Evaluation of Thermochemical Conversion Products:

Research continues as planned; no new data to report.

Metabolomics and Biochemical Analysis – We have also 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 has joined the previous quarter. She has begun processing the metabolomic samples. This work is on track to complete sample processing. Chemical analysis is likely to be delayed in the future due to the back log on the GC/TOF MS system that is down.

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	31 Aug 20
		Manuscripts submitted for peer-review process	31 Aug 20

Manuscript Preparation:

The review article manuscript on pyrolysis conversion of low-cost, higher-nitrogen biomass residues was revised and re-submitted for peer-review by Cheng, now at Worcester Polytechnic Institute, and the authors at NMSU. The other two parts of the review manuscript: one focused on feedstock characteristics and one focused on biochemical conversion methods are still circulating among the authors for editing. (An example graphic from the manuscript is shown in Figure 20.) The methods paper for the development and testing of the pilot-scale

hydrothermal liquefaction (HTL) continuous flow reactor (work in Year 1) was published. The manuscripts on guayule bagasse and resin characterization, including some of the high-resolution FT-MS data for resin composition, were submitted for review and are now under revision.

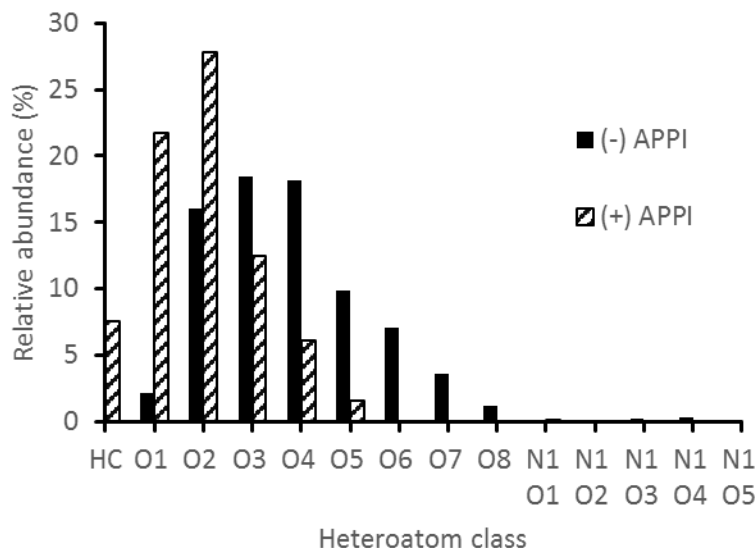


Figure 20. Heteroatom chemical compound class distribution for guayule resin observed using negative- and positive-ion atmospheric pressure photoionization Fourier-transform ion cyclotron resonance mass spectroscopy (APPI FT-ICR MS).

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	31 Aug 20
		Perform liquid-liquid, accelerated, and filtration separations	31 Aug 20
		Prepare manuscript of guayule resin separation	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 is working with the Quinn group at CSU on the guayule resin composition and applications review manuscript with economic information to help down-select target value-added applications. That manuscript is expected to be submitted in Q1 in 2020. Two applications identified for evaluation are polymer tackifiers/modifiers and pesticides.

Dehghanizadeh is collaborating with Reza Foudazi's group in Chemical Engineering at NMSU to design experiments to understand the connection between resin composition and rheological properties. Another collaboration was begun with NMSU's urban entomologist, Alvaro Romero, to investigate the potential of resin/resin derivatives as pesticides (mostly as repellents). His lab's research is currently centered on ways to mitigate the resurgence of bed bugs in North America; his group also works with cockroaches, scorpions, and house flies. Alix Knagg, a senior chemical engineering major, was recruited to do her honors thesis on guayule resin's effectiveness as a pesticide, starting with cockroaches (an easier species to study) and working towards bed bugs during the Spring 2020 semester.

Separations and Fraction Characterization of Guayule Resin:

Rosalez completed the algae + guayule co-HTL conversion tests and is working on product characterization to prepare for his thesis defense in Q2 of 2020.

Chemical and Microbial Transformations:

Cytotoxic activity of pyrimidine analogues of argentatins A–C

Pyrimidine analogues **1–9** of argentatins A–C (see previous report) were evaluated for their cytotoxic activity vs cancer cell lines and normal human cells. Of these, analogues **1, 3, 4, 6** and **9** were found to have enhanced activity and selectivity compared to argentatins A–C. (Table 12)

Table 12. Cytotoxic activity of pyrimidine analogues of argentatins A - C.

Compound	Cancer cell line / IC ₅₀ (μM)		Normal cells / IC ₅₀ (μM)
	Non-small cell lung (NCI-H460)	Breast (MCF-7)	Fibroblast (WI-38)
2-Aminopyrimidine analogue of argentatin A (1)	4.01±0.79	3.76±1.01	9.80±1.02
2-Pyrimidone analogue of argentatin A (3)	4.38±0.66	4.03±0.39	10.47±0.58
2-Aminopyrimidine analogue of argentatin B (4)	3.82±0.84	5.71±0.63	8.16±1.16
2-Pyrimidone analogue of argentatin B (6)	3.95±0.28	3.59±0.14	5.88±0.47
2-Pyrimidone analogue of argentatin C (9)	3.43±0.66	4.07±0.81	10.16±2.91
Positive Control (Doxorubicin)	0.06±0.01	0.22±0.06	0.80±0.10

Evaluate Major Metabolites of Guayule:

Microbial transformations of argentatins A–C

So far, all our attempts to prepare value-added products of argentatins A–C by microbial transformations using the microorganisms, *Rhizopus stolonifer* and *Cunninghamella echinulate*, failed.

Additional chemical transformations of argentatins A–C

In addition to pyrimidine analogues (1–9; see 2019 Q3), semi-synthesis of six novel ring A-fused thiazole and indole analogues (10–15) of argentatins A–C (Figure 21) were completed. These analogues will be evaluated for their potential anticancer (cytotoxic) and antimicrobial activities.

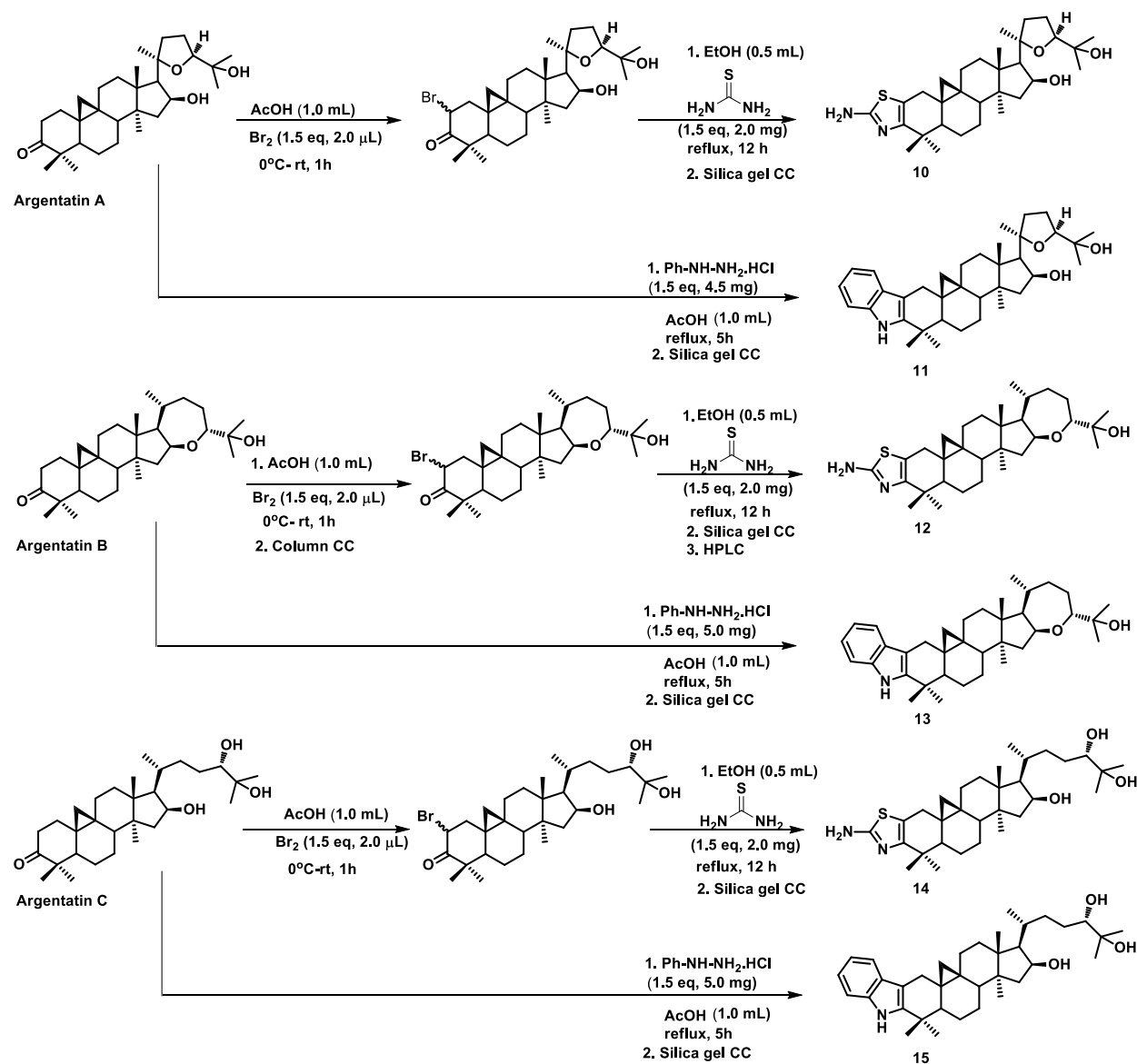


Figure 21. Ring A fused thiazole analogues (10, 12, 14) and indole analogues (11, 13, 15) of argentatins A–C.

Isolate and Characterize Major Metabolites of Guayule Terpene Solution:

The guayule terpene solution (200.0 g) was subjected to steam distillation providing a complex mixture of essential oils (14.0 g; 7%) as judged by its TLC analysis. Further work on separation of constituents of this mixture by fractional distillation etc. is in progress.

Major Fractions of Guayule Resin:

We study the project sustainability and the potential of high-value-added products obtained from guayule resin. Sarocha Pradyawong will continue to focus on adhesives when she returns. Andrew Smith has developed a set up for fractionating the resin using vacuum distillation. Bridgestone will analyze the fractions for us. The system will first be tested for leaks and controllability using ethanol/water and then vegetable oil. These experiments will begin in February 2020 and hopefully we will start on resin next quarter as well. Collaborating with Dr. Quinn and Dr. Brewer on the incorporation into TEA and this is going well.

Cost Analysis of Potential Resin Products:

No new activity to report.

SYSTEM PERFORMANCE & SUSTAINABILITY

Project Coordination: Colorado State University (Dr. Jason Quinn) leads the bi-monthly 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 deep-dive presentations by individuals across the team. The focus this quarter has been:

- Development of scenario analysis
- Refinement of the integrated model
- Work with industry partner on model validation: included travel to Bridgestone
- Model integration across sustainability focused on validation
- The continued development and validation of individual sub-process models
- Development of a publication of guayule results
- Development of a publication of guar results
- Development of a sustainability team meetings on a bi-monthly basis in support of model integration
- Preliminary investigation of resin economic potential in coordination with post-harvest logistics team

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

Issues/Risks:

Fan: Information used as parameters for the optimization model is a key factor to obtain reliable results. Work has been done through the comprehensive literature review to ensure the parameters are considered within a considerable range. However, the wide range of areas covered by the project makes this task quite challenging. Even though feedback has been received from the SBAR researchers, concrete lists of parameters will be provided on our next presentations for the Research and Sustainability group meetings. Feedback will be highly valuable, especially for Guar, since most of our previous work has been focused on Guayule. Additionally, Daniel Zuniga will attend the New Mexico Crops Conference to obtain and/or validate further information for the model as required.

Landis: One issue is that some field data requests have been unfulfilled or only partially fulfilled over the past 2 quarters, which is delaying progress on integrating field data and developing new scenarios for the model. In an effort to get progress moving again we are scheduling one on one meetings with the leaders of the field trials in order to get a better idea of trial scheduling and encourage data sharing once more.

Teegerstrom: Continue to work with tribal farms and Bridgestone on their interest in collaborating, but changes in tribal farm management and it being lower on their priority list for many of the tribal farms is slowing the process. Looking into two other tribal farms – one in central Arizona and one on the Colorado River.

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 1 st 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	31 Aug 20

		Experimental plots established on Tribal lands	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:

- **2019 SBAR Annual Retreat:** A poster on “The Economic Potential of Producing Guayule in the Southwest United States” was presented at the SBAR Annual Retreat in Tucson.
- **AAIC Conference:** Abstracts on “The Economic Potential of Producing Guayule in the Southwest” and “Import Demand and Potential for Domestic Production of Guar” were submitted for conference poster and oral presentations.
- **IMPLAN:** In an effort to study the economic impacts of guar and guayule, IMPLAN software has been obtained for Arizona, New Mexico and Colorado. A preliminary study on the farm-level impact analysis of guar is progressing using the IO model.

Future plans include the following:

1. Engage growers in understanding potential for future markets for selected alternative feedstock crops – guar and guayule.
2. Encourage participation of producers from two culturally distinct regions of Arizona and New Mexico (Northwestern New Mexico and Northeastern Arizona).
3. Develop producer-level partial budget analysis for guayule and guar, illustrating market and profitability potential under different production management scenarios.

Online Producer Systems Model:

Research is progressing as planned; nothing new to report.

Field Data Transfer:

VeeAnder Mealing has collected several sets of data from the feedstock development team and is converting their various formats to useful excel format for the integration. Data requests have continued, and more data is anticipated in the near future. Thanks to the support of the sustainability team and all field trial collaborators!

First Order LCA Model:

First order LCA model of guar agriculture from literature full article draft is complete. VeeAnder Mealing is working on article revisions.

Integrate Field Data into LCA/TEA Model:

VeeAnder Mealing gave a presentation to the sustainability team on current progress of field data collection and integration. She also led a discussion with the team on collection specifics, organization methods, and proposed approaches for utilizing data and integration options. As data continues to be collected, integration methods are being explored.

Sensitivity and Scenario Analysis for Integrated Model

Nothing new to report.

Techno-economic and Life Cycle Assessment Results:

A variety of efforts were perused 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. As previously reported, an integrated model has been developed and the CSU team continues to work with collaborators in improving the fidelity of individual components of that model. This quarter included integrating a format to support agricultural field data.

Guayule: Multiple efforts were pursued as a part of continuing to advance the modeling work. The primary effort included directly visiting with Bridgestone and performing a model review deep dive. The CSU team traveled to AZ and held a two day working session with Bob White and Dave Dierig at the pilot plant and agro operations facilities. Results from this work included revisiting and updating some of the process modeling work. In addition, scenario analysis has been initiated and partially populated. Last, some preliminary work has started on characterizing economic potential of resin pathways. This initial effort has been coordinated with the post-harvest logistics team. Examples of updated results are provided in Figures 22-23.

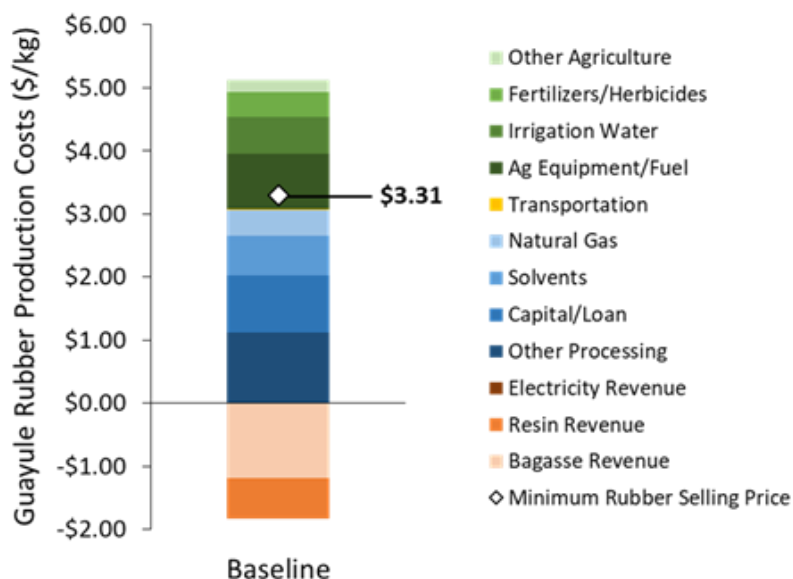


Figure 22. Guayule economic results.

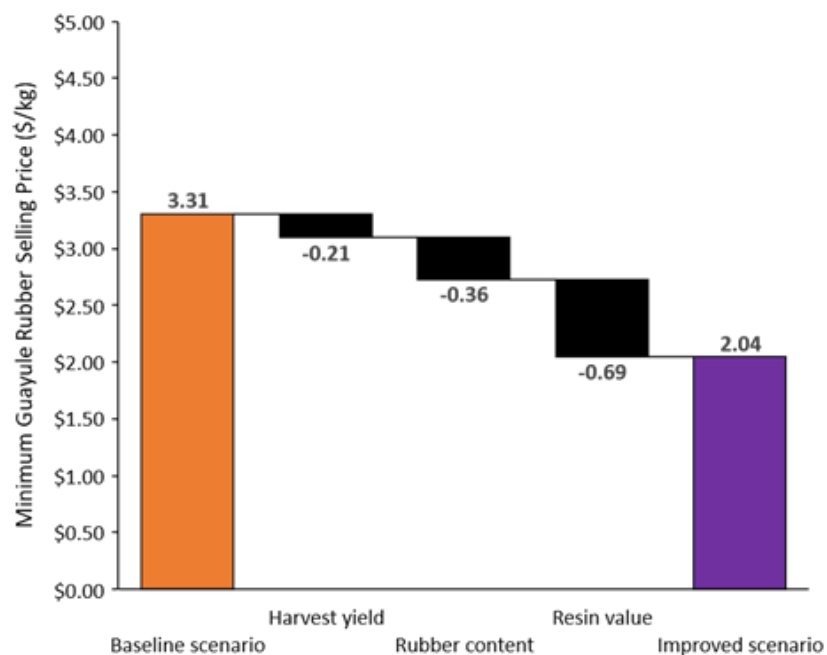


Figure 23. Guayule economic scenario results.

Guar: Work this quarter has included improving the model to include scenario analysis and sensitivity for a better understanding of functionality. Farm level economic modeling has improved with current focus on improvement equipment costs. In addition, the model continues to be updated with new agricultural data as it becomes available from field trials. An example of updated results are provided in Figure 24.

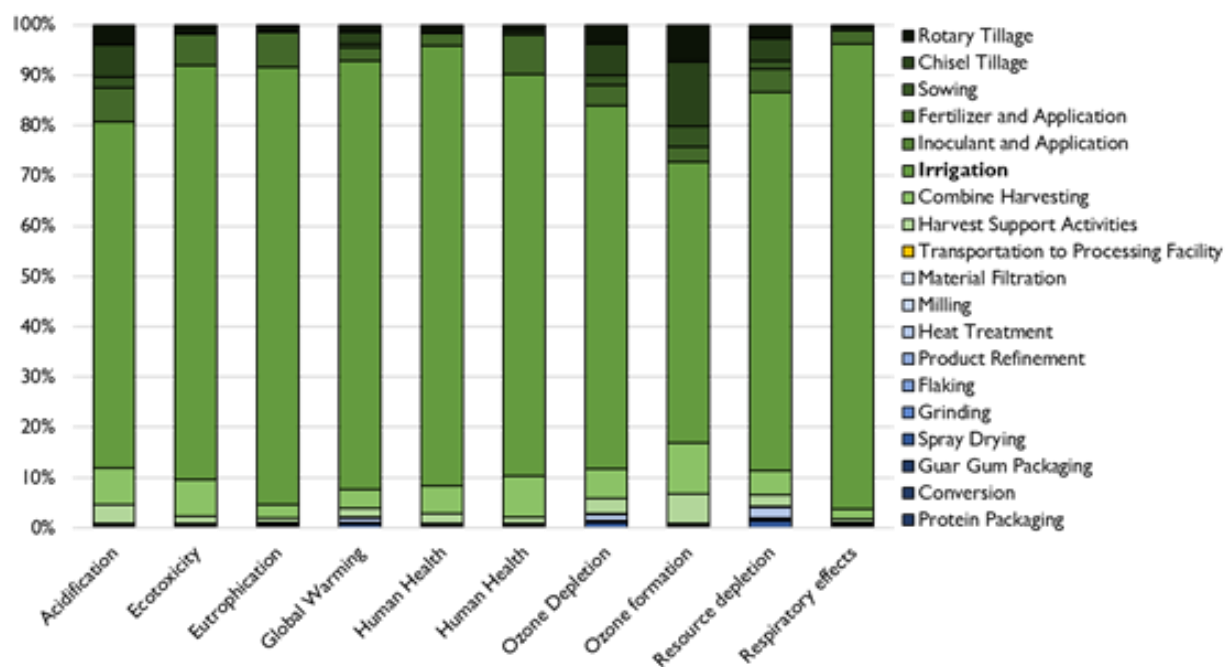


Figure 24. Updated scenario results for guar environmental impacts.

Data Integration:

Experimental data integration represents a critical need for the sustainability team. In collaboration with CSM the agricultural partners have been contacted and we are continuing to work on a format to facilitate the seamless integration of experimental data for model validation. The current hurdle is data collection.

Validated Integrated Model:

Updating the integrated models for guayule and guar by modifying equipment inputs and formulas to be consistent between the two models. New field-level information for guayule and guar has not been forthcoming from producers and researchers, which has delayed validation.

Diversify Integrated Model for Broader Audience:

Updating the integrated model continues with incorporating the costs and returns of fallow and hemp crops. Two future crops, with similar equipment requirements, can also be included with minimal programming requirements.

Facilitate and Foster Relationship between Tribal Farms and Bridgestone:

Continue 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 for experimental acreage agreement. Started the conversation and in the process of setting up the first meeting with both farms, 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.

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 Present results of scenario analysis at conferences for feedback	1 Feb 20 28 Feb 20
3 Quinn	Stochastic modeling	Evaluate system at a system level through Monte Carlo sensitivity modeling	30 Jun 20

Downstream Process Modeling

Over the summer fuel production pathway models were developed with this past quarter including integrating preliminary evaluation on integrating these sub-models into the larger integrated model. The fuel pathways leverage the bagasse as the feedstock and include conversion through pyrolysis, Fisher-tropsch, and palletization.

Scenario Analysis:

Work is on-going to develop different scenarios. This has included the development of a heat and power scenario in the guayule model. The concept is to divert the bagasse to an onsite combined heat and power plant to generate and supply electricity and heat to the processing facility. It is assumed excess electricity is sold to the grid and excess heat is vented.

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	30 Nov 19
		Generate publication/presentation for conference proceedings	30 Apr 20
2 Landis	Social sustainability	Collect data from annual SBAR meeting	31 Dec 19
		Data analyzed and report drafted	31 Aug 20

Clarify Social Sustainability Metrics:

The framework for addressing social sustainability is revolving around the United Nations’ sustainable development goals that are most relevant to the SBAR project. (Figure 25)

Social Sustainability:

Summarized data from social sustainability breakout session at SBAR retreat has been used to identify appropriate indicators from current literature.



Figure 25. United Nations' sustainable development goals most relevant to SBAR.

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	31 Mar 20
		Manuscript submitted to peer review journal	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	31 Aug 20
		Data/model/algorithm shared for Yr4 research (integration of 3 decision modules)	31 Aug 20

Comprehensive Sustainability and Regional Economics Analysis:

In Quarter 4 of 2019, based on the most likely crops to switch to guayule – cotton, grains, and oilseeds, (identified by Trent Teegerstrom, Clark Seavert, Sita Khanal, and Paul Gutierrez) an extensive data collection was performed for the counties of Pinal and Maricopa in Arizona. The data set included the number of farms, location, acres, type of crop, and their variation over the past 10 years using GIS software. Based on the detailed farm information, additional facility locations were identified. (Figure 26) The parameters for the irrigation water used per crop were determined based on the feedback from the Research Meeting Group presentation.

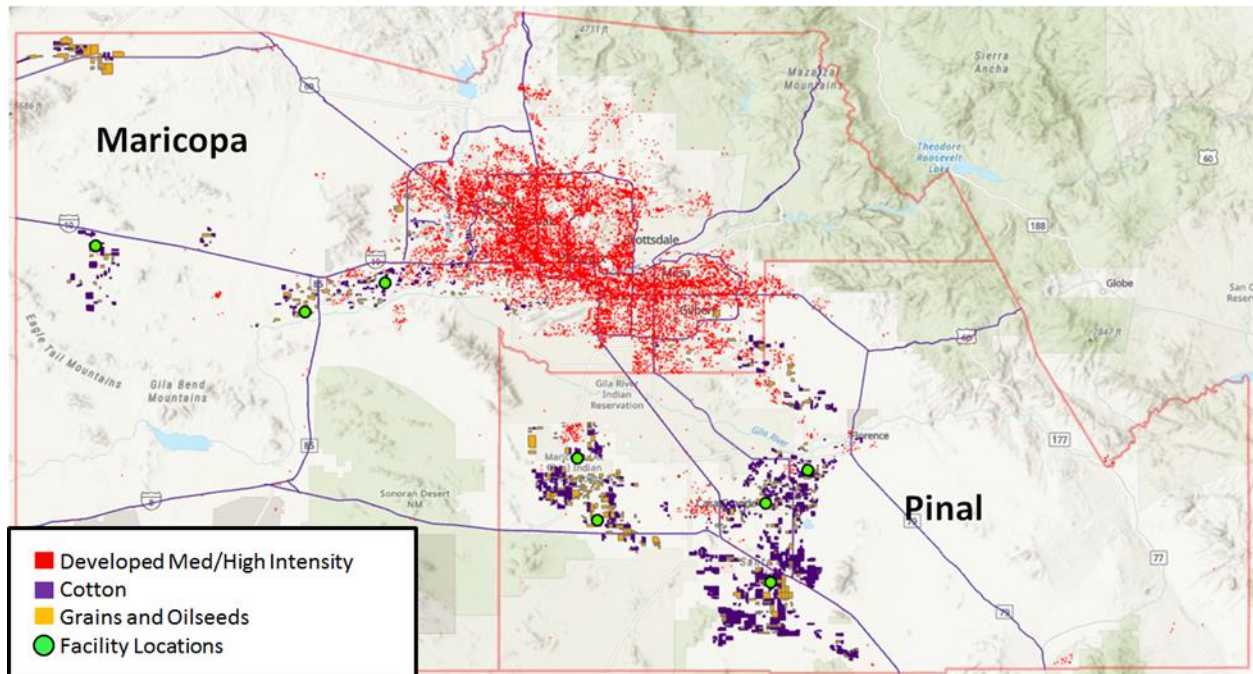


Figure 26. Identified facility locations based on most likely crops to switch to guayule in Maricopa and Pinal Counties, Arizona.

Integer Optimization Approaches for Smart Farm Production/Scheduling:

We continued the literature review to determine which optimization approach will be the most appropriate one for the smart farm production planning and scheduling model. Even though several options have been identified, there are still some papers we require to review before proceeding to the model design.

System-level Model/Algorithm for Decision Support:

The stochastic scenarios were defined for the two-stage multi-objective optimization model for the guayule supply chain integrating environmental and social impacts, which included several adoption rates and their probabilities for five different cases. The guar stochastic scenarios are discussed with the New Mexico State University researchers. Additionally, based on the feedback from the UA Research Meeting Group, labor per location and construction permits were included in the model. The model is coded using the programming language C++, the solver CPLEX, and the high performance computing (HPC) Ocelote from the University of Arizona.

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 (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: Unusual growing season affected some of the planned activities. Either they were delayed by a season or quality of data was not great, necessitating repeat of the activities.

Fields: The 4-H/Outreach component of the project seems to be at a transition point and could benefit from some direction from project leadership. On the AZ side, the 4-H/outreach leader/Co-PI has changed and I am not aware of the plan for moving forward. On the NM side, Rodriguez-Urbe is creating activities and trying them with a variety of audiences (formal, informal, etc.), but it is unclear if there is a clear direction for their work. They are engaging with FFA as a potentially better path than working through 4-H moving forward, but it is unclear the expected/intended outcomes of their work. A high priority for Q1 of 2020 is to better understand the pathway for the 4-H/outreach activities moving forward in order to develop an appropriate evaluation plan and tools.

Idowu: The on-farm, farmer-managed trials with guar were unsuccessful on two farms during the past season due to weed pressures and a third farmer decided not to plant due to late preparation. Two farm locations where the guar trial failed are in organic production systems. The plan next year is to work with conventional farmers who have herbicide options for weed control, to ensure the success of the trials. The guayule on-farm trial could not take place due to lack of seeds from Bridgestone. We hope that seeds will be available during the next season for farmers to plant.

Rock: One of the suggestions from the SBAR annual meeting, included the idea of training the SBAR *Project Puente* interns in a skill that would be beneficial to the mentors. One of these ideas was the generation of on-line social media content or fact-sheet/publication writing. We have taken this idea back to the extension teams for inclusion in the 2020 year of interns.

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	31 Aug 20
		Create videos of guar germination and growth	31 Aug 20
		Provide photos and videos for publication	31 Aug 20
2 Angadi	Guar agronomy research	Gather/analyze data; develop peer-reviewed article on N and P fertilization study	31 Aug 20
		Train graduate students in guar agronomic management	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	31 Dec 19
		Spring tools developed/refined; evaluation data gathered	31 May 20
		Summer tools developed/refined; evaluation data gathered	31 Jul 20
		Data synthesized; evaluation report generated	31 Aug 20
7 Grover	Establish guar trial and showcase guar as potential crop in NM	Host field day	31 Aug 20
		Collect data; results synthesized	31 Aug 20
		Generate peer-reviewed Extension publication	31 Aug 20
8 Grover	Guar demonstration	Identify farm willing to host a demonstration field trial	31 Aug 20
		Collect data; results synthesized	31 Aug 20

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

		Summer eval data gathered	31 Jul 20
		Eval info synthesized; report generated	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	31 Aug 20
		Enterprise budget and BENCO Model available online	31 Aug 20
18 Teeg	Participate in Extension meetings; disseminate economic info for guar and guayule	Provide 2 presentations to growers in NM	31 Aug 20
		Provide 2 presentations to growers in AZ	31 Aug 20

Guar Photographs and Videos:

We are working on protocol for photographs and videos. Our preliminary time-lapse video was well received. We are refining the method and make those videos represent research or extension objectives (e.g. temperature on germination), so that they are more useful. We have started working on them.

Guar Agronomy Research:

Guar Nitrogen and Phosphorous response study was harvested. Samples were threshed and preliminary observations were recorded at Clovis. Plant samples were also ground and prepared for nutrient content analysis. All samples will be sent to Dr. Idowu for nutrient content analysis.

Guar Critical Stage Irrigation Study:

We worked on harvesting and processing guar irrigation study samples. The growing season was unusual and did not favor most summer crops. Frequent rainfall in the region affected planting different crops and growing season was wet with frequent rains. However, there was spell of very hot and dry period that affected growth and yield of crops. Our preliminary data indicates guar yields were extremely low and irrigation treatment effects were masked by wet growing season.

Produce Guayule Newsletter Articles:

The SBAR Newsletter was sent to 319 subscribers to Central AZ Extension Newsletter in December. (Appendix 2)

Develop Outreach Documents for Guayule:

USDA Plant Guide format has been received and literature review has begun.

Design and Implement Evaluation Tools:

Grower-Focused Extension – Evaluation for the grower-focused extension group centered largely on providing suggestions for the newsletter that was recently published. Fields

suggested using a map for a number of purposes. First, it would be helpful in tracking their outreach efforts geographically to ensure that they are reaching stakeholders in the regions of AZ and NM where the guar/guayule bioeconomies should develop. Second, it may be helpful in 'recruiting' potential growers and others interested in the project by including a map in the newsletter to illustrate the growing areas that are viable for the two crops.

Showcase Guar as Potential Crop in New Mexico:

Efforts were invested in creating awareness and disseminating information about the SBAR project with focus on guar as a potential alternative crop in the region through field demonstration, and presentations at a professional meeting and farmer field. Attended International Annual Meetings ASA-CSSA-SSSA", ASA-CSSA-SSSA Tri-society, San Antonio, TX, USA (November 10, 2019 - November 13, 2019).

Guar Demonstration:

Visited grower fields and conducted farmer field demonstration on guar, Anthony, NM (October-December, 2019).



Photo 12. SBAR Researcher, Kulbhushan Grover visiting with farmers in New Mexico.

Develop Extension Programs and Reports for Guar/Guayule Demonstrations:

Multiple Extension publications are currently under review. ((1) Impact of using guar as a rotation crop on cotton production in American Southwest – under peer review; (2) Guar and guayule cost of production fact sheet – under peer review)

Travel to Conferences:

Nothing new to report.

Establish Guayule and Guar Trials in New Mexico:

During this quarter, attention was focused on harvesting and processing various on-station trials that were planted during the summer of 2019. Trial locations included Leyendecker Plant Science Center and Agricultural Science Centers at Los Lunas, Clovis and Tucumcari respectively. All trials were successfully completed, and harvested products are being processed.



Photo 13. Guar fertility trial, Clovis, New Mexico.

Establish On-Farm Demonstration Trials:

Nothing new to report.

Host Guar-Focused Conference for Producers and Ag Professionals:

A committee was constituted in NM to plan the NM Alternative Crops Conference that has been scheduled for March 10th, 2020. The conference venue has been secured in Portales, NM and speakers are currently being contacted.

Newsletter to Inform Stakeholders:

We completed the first SBAR Grower Extension Newsletter that was sent to stakeholders in NM and AZ in December. (Appendix 2)

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.

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. Develop the plan for integration of whole farm adoption tool and collect information during the 4 grower presentations.

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.

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 Present guayule production to Native American farming communities	31 Aug 20 31 Aug 20 31 Aug 20

		Collect needs assessment information directly from Native American farming communities	
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:

Started planning for the Alternative Crops Workshop. Crops to be covered, workshop date and location were decided by the organizing committee. The workshop will be held at Portales, NM on March 10th. I am working on identifying speakers, inviting them and preparing the program.

Establish Farm Demonstration Site in New Mexico:

Nothing new to report.

Grower Workshops in Arizona:

Weed control experiments were presented at the Annual Farmer Field Day hosted at the Maricopa Ag Center on 8 October 2019, where 55 participants had an opportunity to ask questions and learn more. (Photo 14; Appendix 3)

No progress has been made yet for providing guayule production information to Native American farming communities.



Photo 14. SBAR Researcher, Bill McCloskey, discusses guayule weed management trials with Arizona producers.

An SBAR booth highlighting guayule was provided at the Cooperative Extension Day hosted at Maricopa Agricultural Center (12 October), where 210 individuals were directly contacted (of that, 71 were youth) from Maricopa, Pima, and Pinal Counties. (Appendix 4)

Grower Workshops in New Mexico:

Served on WSARE advisory council and involved in the planning of New Mexico Sustainable Agriculture Conference, Los Lunas, NM, (12 December 2019).

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	31 Aug 20
		Plan/Host 15 SBAR school enrichment events	31 Aug 20
		Host a train-the-trainer camp for 4H Agents and teachers	31 Aug 20
		FFA Science Fair: Promote SBAR curriculum use	30 Jun 20
3 Rock	Develop SBAR internal factsheets on <i>Project Puente</i>	Generate <i>Project Puente</i> resource document(s) for SBAR faculty	28 Feb 20
4 Rock	Recruit students for summer <i>Project Puente</i> internships	Update application materials to highlight on-going SBAR research opportunities	1 May 20
		Recruit 6 students for Yr3 cohort of <i>Project Puente</i> interns	1 May 20
5 Rock	Recruit faculty mentors for summer <i>Project Puente</i> internships	Recruit 5 faculty mentors for Yr3 cohort of <i>Project Puente</i> interns	1 May 20
6 Rock	<i>Project Puente</i> student project development and deployment	Work with SBAR faculty to identify appropriate internship projects (research and extension)	26 Jul 20
		Facilitate SBAR internship projects; final poster presentations highlighting student work	31 Aug 20
7 Rock	<i>Project Puente</i> case study video	Design and develop short video highlighting student/mentor experiences for future training needs	31 Aug 20

SBAR 4-H Camp Curriculum:

Curriculum was developed and used in the train the trainer and in the SBAR 4H Day camps and/or mini-camps. SBAR FFA curriculum is currently under development for use by High School FFA instructors.

SBAR 4-H Day Camps or Mini-Camps:

Gutierrez and Rodriguez-Urbe organized and facilitated a meeting with the FFA Executive Secretary to discuss the possibility of including the SBAR activities in the FFA curriculum (in October). A draft of the first modified SBAR curriculum/lesson plan (Separation of a Mixture) was submitted to FFA for review on 9 December. Hosted a workshop for 97 students at Alamogordo High School (Las Cruces, NM) from an Agriculture class whose teacher is a FFA advisor. (Photo 15)

NMSU will host a 4-H/FFA Train the Trainer camp in July 2020 (date TBD). NMSU will also participate in the FFA Science Fair to promote the use of SBAR curriculum.

Internal Factsheets on *Project Puente* Internships:

During year three, 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 is 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 goal will be to increase participation to a total 6 student interns participating in the project in year three. Our goal will be to increase participation to a total of 5 SBAR faculty participating in the project in year three. At the culmination of year three, the extension team will also create a short case study video to highlight the success of the program.



Photo 15. Alamogordo High School students participating in an SBAR-focused activity, December 2019.



Photo 16. SBAR Project Puente 2019 Interns collecting recycled water used for agriculture, Maricopa, Arizona.

Project Puente Internship Recruitment:

Nothing new to report.

Project Puente Student Project Development and Deployment:

One of the tactics that we used last year that we will continue this year, to better facilitate meaningful student intern experiences, will be to partner with new 4H STEM specialist to recruit a local high school students in Tucson for the Extension team. Additionally, in-order to aid in information transfer to student interns across the state, we arranged for Zoom classroom sessions that linked Maricopa and Phoenix-based students with those in Tucson. We feel that this is a successful model for future engagement of students in year 2020 of the grant.

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 weekly 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 relationship between the SBAR fellow/teacher activities, and the 4-H activities, especially the “boot camp” for early summer 2020 for SBAR interns and 4-H trainers, is still not clear. Brewer and the UA team anticipate that the videos/media resources created in the spring towards the teacher PD would be helpful. More clarity on dates, roles, and responsibilities for the “boot camp” is needed.

Rodriguez-Urbe at NMSU has begun communicating more with Brewer about upcoming 4-H activities and needs regarding grad/undergrad student helpers. Brewer expects that Usrey will devote a portion of his Fellow hours to assisting with these activities, especially in the summer to make up hours unfulfilled during the school year. He has been and is planning to continue work as a science teacher’s aide at Highland Elementary for 4th and 5th grade, and as an assistant with the GOB afterschool program at Lynn Middle School.

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 2018-2019 school year	Design/deliver after school program for middle school	31 May 20
		Design/vet STEM activities	31 May 20
2 Brewer	Recruit and train SBAR Fellows and Teachers for 2019-2020 school year	Identify 4 new NM SBAR Fellows and any replacements, as necessary	31 Jul 20
		Identify 4 new NM SBAR Middle school teachers	31 Jul 20
3 Chav	Plan/Design/Coordinate Fall 2019 and Spring 2020 SBAR Fellow seminar	Plan Fall 2019 seminar content	31 Aug 19
		Plan Spring 2020 seminar content	31 Dec 19
		Generate education products on SBAR Fellow activities (digital publications)	31 Jul 20
4 Chav	Visit classrooms for observations (delivery of SBAR content)	Implement Fall teacher observation	30 Nov 19

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

Assist NM SBAR Fellows and Teacher Mentors (2019-2020):

Every two weeks, the fellows met with Brewer to review progress, work on their lesson plans, and to discuss readings/presentations from the UA fellows' seminar. Each fellow completed a draft lesson plan, a teacher interview, a weekly activity log (classroom and afterschool program), and collection of participant demographic data, all submitted through the Box folder. Usrey organized SBAR-related demos (pyrolysis s'mores and guar gum bubbles) for Highland Elementary School's *Math & Science Night* in November. All fellows continued to work with the *Guardians of the Biosphere* (GOB) afterschool programs.

Recruit and Train SBAR Fellows and Teachers (2019-2020):

Work continues as planned; nothing new to report.

SBAR Fellow Seminar (Fall 2019 / Spring 2020):

The second half of the Fall SBAR Seminar focused on topics such as classroom management strategies/engagement, culturally relevant pedagogy and an overview of our lesson design goals. Each Fellow made a micro presentation of their lesson and received feedback from the team. They also participated in a peer to peer review of their lesson. Additional lesson support came from their partner SBAR teacher reviewing their lesson and providing feedback. The Seminar ended with fellows presenting their revised lesson plans and demonstrating one of the hands-on activities from their lesson (PPT, game, activity, etc.). After the final class, fellows presented their lesson plan ideas to the UA SBAR research group, fielded questions and explored additional connections to the project. Presenting to the researchers was a useful new addition to the project to connect the fellows and researchers.

Classroom Observations (Delivery of SBAR Content):

Knox and Anderson visited teacher/fellow classrooms, to see their partnership in action. This was helpful to see how different pairs incorporated SBAR into their classrooms. For example, three of the pairs of teachers/fellows currently host an “SBAR Friday” where the fellow is in the classroom on Fridays to provide SBAR content. While the other pairs work to incorporate SBAR content into the daily week structure.

Highlights of the classroom visits include the entire SBAR fellow group attending a presentation of Jamie Camero’s students presenting to their school board on heat islands. Attending this event as a team and meeting with Jamie afterwards to learn about her students/classroom management approach gave fellows a common real world example to discuss. The class visit to Melissa Wilburn’s class allowed Anderson to conduct an interview with her about her recent honorable mention as Arizona Middle School Science Teacher of the Year, which was mentioned as an SBAR Highlight on the website and in the Extension Newsletter.

Chavarria, Knox and Anderson also traveled to Sells, Arizona on the Tohono O’odham Nation to visit SBAR teacher/fellows working with students at the Santa Rosa Ranch School. (Photo 17) This class visit was different in that we were also able to attend a school assembly, meet with the principal and speak to Felecia Hinton-Causey’s class about SBAR. The SBAR fellows are adding a unique component to the students’ learning and one student said that “SBAR was her favorite part of school because it was something different.” The trip was important to demonstrate to the school how we value this collaboration and also for us to learn first-hand about a school on Tohono O’odham Nation.



Photo 17. SBAR Education Team members Chavarria, Knox, and Anderson with SBAR Fellow/Teacher Mentor Teams (Tenzin Phakdon/ Felicia Hinton-Causey; and Huitzilil Ortiz/ Valentina Andrew) visiting Santa Rosa Ranch School, Tohono O’odham Nation, Sells, Arizona.



Photo 18. School assembly, Santa Rosa Ranch School, Tohono O’odham Nation, Sells, Arizona.

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

Design and Implement Classroom Evaluation Tools:

During the fourth quarter of 2019, the primary tasks related to the evaluation of the EEO components of the SBAR project were to 1) participate in team meetings to prepare for the refinement and development of evaluation plans/tools for spring/summer activities, 2) continue to analyze evaluation data collected during summer 2019; 3) review documents/project artifacts such as teacher and fellow lesson plans to monitor progress towards curriculum deliverables; and 4) upload evaluation materials and findings to the SBAR EEO Box folder.

Evaluation activities for the education group largely centered around continued analysis of the summer data to inform plans for the new digital format for the summer 2020 Professional Development activities (Figure 27). The analysis is still in progress and will result next quarter in a report that will guide the PD in terms of teacher and fellow feedback that indicates activities that were 1) most impactful in developing their content knowledge and understanding of key SBAR concepts; 2) most efficient regarding time spent; 3) most enjoyable; 4) most relevant to planning for their classroom experience as well as other indicators that will help guide the format and content of the PD sessions. During Q1 of '20, this analysis will be given to the SBAR project staff and discussed in order to incorporate formative evaluation feedback into programmatic planning. Other evaluation activities included reviewing documentation and artifact in the box folder that have been submitted by teachers, fellows, and project staff as they relate to curriculum development. Two lessons have been formatted and finalized and are ready for posting to the website.

SBAR 2019 Summer Camp Curriculum Feedback
Camper Activity Rubric

Day of Camp	Activity Title	New or Repeat activity for 2019	I had FUN doing this activity	I LEARNED something new doing this activity	This activity made me CONSIDER being A SCIENTIST		Activity Title	Total Fun/Engagement		Total Learning		Total Science Identity		Total Overall	Ranking Overall	
			MOST FUN	MOST	SCIENTIST	MOST		Points	Ranking	Points	Ranking	Points	Ranking			
Day 1	Carbon Footprint	Repeat	7	5	13	10	9	7 Footprint	12	16	23	10	16	10	51	14
Day 1	Photosynthesis	Repeat	11	9	17	14	11	9 Photosynthesis	20	14	31	2	20	6	71	6
Day 1	Biofuel Blast	Repeat	18	15	15	13	6	3 Biofuel Blast	33	1	28	4	9	16	70	7
Day 1	Cellulose Lab (part 1)	Repeat	15	14	14	13	16	16 (part 1)	29	4	27	5	32	2	88	2
Day 1	Mixture's Separation (Pt 1)	New	5	5	5	5	6	5 Separation	10	17	10	16	11	13	31	16
Day 2	Scientific Methods	Repeat	10	7	11	6	6	2 Methods	17	15	17	15	8	17	42	15
Day 2	Burn a Nut	Repeat	18	14	11	10	10	6 Burn a Nut	32	2	21	12	16	10	69	8
Day 2	Oil Extractor	Repeat	16	13	15	11	1	10 Oil Extractor	29	4	26	6	11	13	66	11
Day 2	Mixture's Separation (Pt 2)	New	12	9	11	7	11	6 Separation	21	10	18	14	17	9	56	13
Day 2	Plant Defenses	New	17	11	14	10	15	9 Separation	28	7	24	9	24	4	76	5
Day 2	Cellulose Lab (pt 2)	Repeat	12	9	15	10	13	9 (pt 2)	21	13	25	7	22	5	68	9
Day 2	Polymerization	Repeat	12	9	15	10	13	9 (pt 2)	21	13	25	7	22	5	68	9
Day 3	Reactions	New	16	11	17	13	11	9 Reactions	27	11	30	3	20	6	77	4
Day 3	Fats, Lipids & Fatty Acids	New	7	5	4	2	7	4 Fatty Acids	12	16	6	17	11	13	29	17
Day 3	Biodiesel Lab	Repeat	17	12	14	8	16	11 Biodiesel Lab	29	4	22	11	17	8	78	3
Day 3	Cellulose Lab (Pt 3)	Repeat	14	9	15	10	11	8 (Pt 3)	23	12	25	7	19	8	67	10
Day 3	Careers in Biohules	Repeat	6	3	4	2	2	0 Biohules	9	18	6	17	2	18	17	18
Day 3	Bingo	Repeat	6	3	4	2	2	0 Biohules Bingo	9	18	6	17	2	18	17	18
Day 4	Cellulose Lab (Pt 4)	Repeat	15	13	18	15	18	17 (Pt 4)	28	10	33	1	35	1	94	1
Day 4	Student Presentations	Repeat	17	13	10	9	9	5 Presentations	30	3	29	13	14	12	63	12

Figure 27. Screenshot of evaluation data under analysis.

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	31 Jul 20
		Recruit 4-H youth and GK-12 participants	31 Jul 20
2 Chav	Edit Cohort 1 lessons and materials for online publication	Edit lessons	31 Oct 19
		Submit final lessons/activities for SBAR website and online publication	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:

Brewer continued working with the UA education team to refine the plans for summer 2020 training/professional development (PD) and SBAR education implementation in Years 4 and 5. The budget, scope, and deliverables were revised to have an online summer teacher PD going forward and website publication of fellow-developed lesson plans with videos/multimedia added in spring 2020 for Year 3. For Year 4, the plan is to have two teacher/fellow pairs (one in Las Cruces and one in Clovis), and one additional fellow to support five new NM teachers from target counties who do the online summer 2020 PD. In Year 5, the plan is to have one fellow to support NM teachers remotely before, during, and after the online PD workshop(s).

Cohort #1 Lessons and Materials:

A work study student, Gunnar Fritz, was hired to revise the lesson plan template and to put finished lessons into the template. A lot of time was spent editing and revising fellow lesson plans by the SBAR Education Team. The review process included giving feedback/notes for the fellows to incorporate, looking up standards, reviewing for educational quality, looking for photographs for the lesson, checking for copyright materials, author attribution, review within the educational team for content and line editing. For most of the fellows, lesson design is a new experience and considerable time was spent in the seminar and in one on one meetings discussing the components of a good lesson plan. Two edited lessons were submitted for the SBAR website educational resource page. Because of the intensive nature of the lesson plan revision, Knox and Anderson will schedule one on one in-depth meetings with fellows to go over the revision needs of their lessons in Spring 2020.

Support Lesson Plan Design by Teacher-Fellow Partnerships:

The UA Education team met monthly with Catie Brewer at NMSU to share the plan/activities of the UA Fellows to support her work with NM fellows. This included bi-monthly meetings when requested, providing PPT of seminar classes at UA and strategizing with Brewer about her plan with NM fellows. These regular meetings helped connect NM and AZ Education and highlighted the need for more on the ground support in NM such as classroom visits to SBAR teachers/fellows in NM.

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

2019

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

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

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

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

PRODUCTS GENERATED.

September 2017 – December 2019

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. **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.
3. **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.
4. **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.
5. **Cheng, F.; Dehghanizadeh, M.; Audu, M.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. ND.** Characterization and evaluation of guayule bagasse and processing residues as potential feedstock for biofuel and chemical production. *Industrial Crop & Products*, in revision.
6. **Dehghanizadeh, M.; Cheng, F.; Jarvis, J.M.; Holguin, F.O. Brewer, C.E. ND.** Characterization of resin extracted from guayule (*Parthenium argentatum*): a dataset including GC-MS and FT-ICR MS. *Data in Brief*, under review.
7. **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.
8. **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>
9. **Sun, O.; Fan, N. ND.** A Review on Optimization Methods for Biomass Supply Chain: Models and Algorithms, Sustainable Issues, Challenges and Opportunities. *Process Integration and Optimization for Sustainability*, revised, under review.

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. **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.
5. **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.
6. **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.
7. **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.
8. **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.
9. **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.
10. **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.
11. **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.
12. **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.
 13. **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. **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.
7. **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]
8. **Brewer, C.E. 2018.** *Pairing biomass residues with conversion technologies.* Advanced Bioeconomy Leadership Conference, Washington, D.C. 28 February.
9. **Brewer, C.E. 2018.** *Polymerization and guar gum bubbles.* Outreach event activity. New Mexico 4-H State Conference. 11 July.
10. **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.
11. **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]

12. **Brown, K.S.*; Neilson, J.W. 2018.** *Microbial contributions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. April.
13. **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]
14. **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]
15. **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.
16. **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.
17. **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.
18. **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.
19. **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, Pittsburgh, Pennsylvania. 1 November.
20. **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.
21. **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]
22. **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.
23. **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]
24. **El-Shikha, D.E.M. 2018.** *Update – Guayule irrigation experiments at Maricopa Agricultural Center*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 12 September.

25. **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]
26. **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]
27. **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]
28. **Evancho, B. 2018.** *Guayule Fuels the Future.* IES – Energy Talks Seminar, Sky Bar, Tucson, Arizona. 9 October.
29. **Evancho, B. 2019.** *Guayule: How Close Are We?* Marana Winter Field Crops Clinic. Marana, Arizona. 10 January.
30. **Evancho, B. 2019.** *Guayule: How Close Are We?* Casa Grande Winter Field Crops Clinic. Casa Grande, Arizona. 15 January.
31. **Evancho, B. 2019.** *Comparing direct-seeded and transplanted guayule roots.* SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 13 November.
32. **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]
33. **Fan, N. 2018.** *Review on Optimization Methods for Biomass Supply Chain.* SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
34. **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.
35. **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]
36. **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.
37. **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.
38. **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.

39. **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]
40. **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]
41. **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.
42. **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.
43. **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]
44. **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.
45. **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.
46. **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]
47. **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]
48. **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.
49. **Grover, K. 2018.** *Sustainable agriculture and guar production in New Mexico.* New Mexico State 4-H Conference, Las Cruces, New Mexico. 10 July.
50. **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.
51. **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.
52. **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.

53. **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.
54. **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.
55. **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.
56. **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]
57. **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.
58. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico*. New Mexico Master Gardener's Meeting. Las Cruces, New Mexico. 8 May.
59. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. New Mexico Sustainable Agriculture Field Day. Las Cruces, New Mexico. 26 June.
60. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. SBAR Train-the-Trainer Workshop. Las Cruces, New Mexico. 2 July.
61. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico*. SBAR Train-the-Trainer Workshop. Las Cruces, New Mexico. 2 July.
62. **Grover, K. 2019.** *Guar research and extension program in New Mexico*. Departmental External Review, Las Cruces, New Mexico. 10 October.
63. **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.
64. **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.
65. **Hoare, D.M. 2018.** *Irrigation Sensors and the WINDS Model*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 26 September.
66. **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]
67. **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 WRRRC, Albany, California. 18 November.
68. **Idowu, O.J. 2018.** *Introduction to the SBAR Project*. Las Cruces, New Mexico. 6 Feb.
69. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Update*. Extension Field Day, Clovis, New Mexico. 9 August.
70. **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.

71. **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.
72. **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.
73. **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]
74. **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]
75. **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.
76. **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]
77. **Lewis, M. 2019.** *Salt stress tolerance in guayule*. SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 23 October.
78. **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]
79. **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.
80. **Lopez, E.*; Fox, S.; Brewer, C.E. 2018.** *GK-12 Lesson Documentation Spreadsheet*. American Institute of Chemical Engineers Annual Meeting, Pittsburgh, Pennsylvania. 29 October.
81. **Maqsood, H. 2018.** *Guar Crop Coefficient Development for New Mexico Environments*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 7 November.
82. **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]
83. **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]
84. **McCloskey, W. 2018.** *Weed Trial Results for Guayule*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 14 November.
85. **McCloskey, W. 2019.** *Guayule Weed Control Research*. The 9th Annual Central Arizona Farmer Field Day. Maricopa Agricultural Center (MAC), Maricopa, Arizona. 8 October.

86. **McMahan, C. 2018.** *Flowering Reduction in Guayule*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 19 September.
87. **McMahan, C. 2019.** *USDA-ARS Rubber Lab Update*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 27 March.
88. **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]
89. **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.
90. **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.
91. **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]
92. **Mealing, V. 2019.** *Field Data Collection and Integration*. SBAR System Performance and Sustainability Seminar, Colorado State University, Fort Collins, Colorado. 13 November.
93. **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.
94. **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.
95. **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]
96. **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]
97. **Mealing, V.S.*; Landis, A.E. 2019.** *SBAR Sustainability*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
98. **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]
99. **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]
100. **Niu, D., 2018.** *Partial cloning of APETALA1 (AP1) gene from guayule*. cDNA Lab Seminar, USDA-ARS Western Regional Research Laboratory. 28 March.

101. **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]
102. **Ogden, K. 2017.** *Sustainable Bioeconomy for Arid Regions.* Biomass Research and Development Technical Advisory Board Meeting. 15 November. [invited speaker]
103. **Ogden, K. 2018.** *Sustainable Bio-economy for Arid Regions.* Southwest Indian Agricultural Association Annual Meeting. Laughlin, Nevada. 16-18 January.
104. **Ogden, K. 2018.** *Potential of the Bioproducts and Biofuels Economy.* AIChE Annual Meeting, Pittsburgh, Pennsylvania. October [invited speaker]
105. **Ogden, K.*, White, R., Brewer, C.E. 2018.** *Public Private Partnerships.* ABLC Conference. Washington, D.C. 27-28 February.
106. **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]
107. **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]
108. **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.](#)
109. **Rock, C.*; Brassill, N. 2018.** *Importance of Cooperative Extension in University Research.* University of Arizona, Tucson, Arizona. 14 March.
110. **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]
111. **Rogstad, A. 2019.** *SBAR Overview.* Association for the Advancement of Industrial Crops 31st Annual Meeting. Tucson, Arizona. 8 September. [invited speaker]
112. **Rodriguez-Urbe, L.*; Gutierrez, P. 2019.** *Implementing the Science of SBAR with Youth.* SBAR UA Research Team Seminar, University of Arizona, Tucson. 25 September.
113. **Rosalez, R.*; Brewer, C.E.; Jena, U. 2019.** *Co-Hydrothermal liquefaction (HTL) of guayule bagasse and wastewater treatment microalgae.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
114. **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.](#)
115. **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]
116. **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.

117. 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]
118. 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.
119. Singh, J.*; Angadi, S.V.; Begna, S.H.; Idowu, O.J.; Guzman, I.; VanLeeuwen, D. 2019. *Water extraction patterns 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.
120. 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.
121. 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.
122. 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]
123. 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.
124. 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]
125. 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.
126. 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.
127. 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]
128. Sun, O. 2018. *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty*. INFORMS Annual Meeting, Phoenix, Arizona. 5 November.
129. 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.

130. **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.
131. **Sun, O. 2019.** *Biomass Supply Chain Configuration and Management*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 10 April.
132. **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.
133. **Sun, O.*; Fan, N. 2018.** *Harvest scheduling*. SBAR Logistics Team Group Meeting. (webinar) New Mexico State University. Las Cruces, New Mexico. 5 February.
134. **Sun, O.*; Fan, N. 2018.** *Optimization of feedstock logistics*. SBAR UA Research Seminar. University of Arizona. Tucson, Arizona. 14 February.
135. **Sun, O.*; Fan, N. 2018.** *Optimally locating biorefineries*. SBAR Sustainability Working Group Seminar. (webinar) Colorado State University. Lakewood, Colorado. 8 March.
136. **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.
137. **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.
138. **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.
139. **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.
140. **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.
141. **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]
142. **Waller, P. 2018.** *WINDS Model: A status report and connection to SBAR research*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 10 October.
143. **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]
144. **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.
145. **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]

146. **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]
147. **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]
148. **Zuniga-Vasquez, D. 2019.** *Stochastic scenarios for guayule production*. SBAR System Performance and Sustainability Seminar, Colorado State University, Fort Collins, Colorado. 8 October.
149. **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.

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

Audience Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
Gender			
Males	1,165	79	1,244
Females	506	55	561
Race/Ethnicity			
Hispanic	233	20	253
Asian	143	13	156
Native American	234	8	242
African American	54	3	57
Anglo/White	1,007	90	1,097

Audience Cumulative Total (when captured): 1,805 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). UMW: 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.

→Total Reach via Tabling Events and Workshops (when captured): **2,938 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
<i>Age Level</i>			
11-13 years	1,099	143	1,242
14-16 years	277	156	433
<i>Gender</i>			
Males	674	160	834
Females	702	139	841
<i>Race/Ethnicity</i>			
Hispanic	762	131	893
Asian	27	6	33
Native American	119	40	159
African American	40	7	47
Anglo/White	426	112	538
Multiracial	2	4	6

Youth Cumulative Total (when captured): 1,675 ppl

PARTICIPANTS AND COLLABORATING ORGANIZATIONS.

September 2017 – December 2019

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
<i>Chloe Gonzalez</i>	<i>Intern</i>	<i>Feedstock Development & Production</i>
Amber Lynch	Professional	Feedstock Development & Production
Russell Prock	Professional	Feedstock Development & Production
Theresa Sullivan	Professional	Feedstock Development & Production
Sam Wang	Professional	Feedstock Development & Production
<i>Jocelyn Zhu</i>	<i>Intern</i>	<i>Feedstock Development & Production</i>
Colorado School of Mines		
<i>Pragnya Eranki</i>	<i>Post-doc</i>	<i>System Performance & Sustainability</i>
Amy Landis	Key Collaborator	System Performance & Sustainability
VeeAnder Mealing	Graduate Student	System Performance & Sustainability
Colorado State University		
Austin Banks	Undergrad Student	System Performance & Sustainability
<i>Jack Johnson</i>	<i>Undergrad Student</i>	<i>System Performance & Sustainability</i>
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		
<i>Ram Acharya</i>	<i>Professional</i>	<i>System Performance & Sustainability</i>
<i>Sarah Acquah</i>	<i>Post-doc</i>	<i>Extension & Outreach</i> <i>System Performance & Sustainability</i>
Rowen Allen	Undergrad Student	Extension & Outreach
Sangu Angadi	Key Collaborator	Extension & Outreach Feedstock Development & Production
Matt Armijo	Undergrad Student	Post-Harvest Logistics & Co-Products
<i>Meshack Audu</i>	<i>Graduate Student</i> <i>Fellow</i>	<i>Education</i> <i>Post-Harvest Logistics & Co-Products</i>
<i>Valerie Bailey</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Hengameh Bayat	Graduate Student	Post-Harvest Logistics & 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 Post-Harvest Logistics & Co-Products
Ken Cazarez	Undergrad Student	Extension & Outreach

<i>Nicolas Carrera-Little</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
Pedro Castillo	Undergrad Student	Feedstock Development & Production
Feng Cheng	Post-doc	Post-Harvest Logistics & Co-Products
Mostafa Dehghanizadeh	Graduate Student Fellow	Education Post-Harvest Logistics & Co-Products
Barry Dungan	Professional	Post-Harvest Logistics & Co-Products
<i>Miguel Flores</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
Leonel Fournier	Undergrad Student	Feedstock Development & Production
<i>Sarah Fox</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
Ryan Fullerton	Undergrad Student	Feedstock Development & Production
Alonso Garcia	Graduate Student	Feedstock Development & Production
Adah Gellis	Undergrad Student	Extension & Outreach
Saba Gill	Graduate Student	Post-Harvest Logistics & Co-Products
<i>Thomas Gloria</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Kulbhushan Grover	Key Collaborator	Extension & Outreach Feedstock Development & Production
Erin Gutierrez	Undergrad Student	Post-Harvest Logistics & Co-Products
Paul H Gutierrez	Key Collaborator	Extension & Outreach System Performance & Sustainability
<i>Befekadu Habteyes</i>	<i>Professional</i>	<i>System Performance & Sustainability</i>
F. Omar Holguin	Key Collaborator	Post-Harvest Logistics & Co-Products
John Idowu	Key Collaborator	Extension & Outreach
Jackie Jarvis	Professional	Post-Harvest Logistics & Co-Products
Umakanta Jena	Professional	System Performance & Sustainability
Sita Khanal	Graduate Student	System Performance & Sustainability
Alix Knagg	Undergrad Student	Post-Harvest Logistics & Co-Products
Kelly Laje	Graduate Student	Post-Harvest Logistics & Co-Products
<i>Travis Le-Doux</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
<i>Esai Lopez</i>	<i>Undergrad Student</i>	<i>Education</i>
<i>Alberto Lorenzo</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
<i>Sicilee Macklin</i>	<i>Undergrad Student</i>	<i>Education</i> <i>Post-Harvest Logistics & Co-Products</i>
Michael Mares	Undergrad Student	Extension & Outreach
<i>Cesar Martinez-Bejarano</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
Julie Miller	Undergrad Student	Extension & Outreach
<i>Sa'Rae Montoya</i>	<i>Graduate Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
<i>Kyle Moore</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Hasti Mozaffari	Graduate Student	Post-Harvest Logistics & Co-Products
Mohammed Omer	Graduate Student	Extension & Outreach
<i>Jasmine Paquin</i>	<i>Graduate Student</i>	<i>Extension & Outreach</i>
<i>Kaavya Polisetti</i>	<i>Graduate Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
<i>Camila Prieto</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
Darien Pruitt	Graduate Student Fellow	Education Extension & Outreach
<i>Lucas Ramirez</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Joram Robbs	Graduate Student	Extension & Outreach System Performance & Sustainability
Laura Rodriguez-Uribe	Professional	Extension & Outreach Post-Harvest Logistics & Co-Products
Rodrigo Rosalez	Graduate Student Fellow	Education Post-Harvest Logistic & Co-Products
<i>Kimberly Salinas</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
<i>Nathan Schavz</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
<i>Tarah Schuman</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics & Co-Products</i>

Ujala Sehar	Graduate Student	Post-Harvest Logistics & Co-Products
Parameer Singh	Graduate Student Fellow	Education
Jagdeep Singh	Graduate Student	Education Feedstock Development & Production
<i>Peter Skelton</i>	<i>Professional</i>	<i>Extension & Outreach</i>
Nicolas Soliz	Undergrad Student	Post-Harvest Logistics & Co-Products
Grant Stoner	Undergrad Student	Feedstock Development & Production
<i>Stephen Taylor</i>	<i>Undergrad Student</i>	<i>Education</i>
<i>Brian Treftz</i>	<i>Graduate Student</i>	<i>Education</i> <i>Post-Harvest Logistics & Co-Products</i>
Jacob Usrey	Graduate Student Fellow	Education Post-Harvest Logistics & Co-Products
<i>Justin Valdez</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
Victoria Valenzuela	Undergrad Student	Feedstock Development & Production
<i>Stephanie Willette</i>	<i>Graduate Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
April Wright	Undergrad Student	Post-Harvest Logistics & Co-Products
<i>Scott Woolf</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics & Co-Products</i>
Other		
Jennifer Fields	Professional	Education Extension & Outreach
Clark Seavert	Professional	System Performance & Sustainability Extension & Outreach
University of Arizona		
Torran Anderson	Professional	Education Extension & Outreach
<i>Nick Ashley</i>	<i>Graduate Student</i>	<i>Feedstock Development & Production</i>
<i>Craig Bal</i>	<i>Graduate Student</i>	<i>Education</i> <i>Extension & Outreach</i>
<i>Gloria Vill Barbosa</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
Armando Barreto	Professional	Feedstock Development & Production
<i>Holly Barton</i>	<i>Graduate Student</i> <i>Fellow</i>	<i>Education</i>
<i>Megan Bennett</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Natalie Brassill	Professional	Extension & Outreach
Kyle Brown	Graduate Student	Feedstock Development & Production
Kale Burke	Undergrad Student	Post-Harvest Logistics & Co-Products
<i>Daniela Cabrera</i>	<i>Professional</i>	<i>Extension & Outreach</i>
Madasu Chandrashekar	Professional	Post-Harvest Logistics & Co-Products
Connor Chaney	Undergrad Student	Feedstock Development & Production
Sara Chavarria	Key Collaborator	Education
Yongjian Chen	Post-doc	Feedstock Development & Production
<i>German Coronado</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Kamel Didan	Professional	Feedstock Development & Production
Cara Duncan	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	Post-Harvest Logistics & Co-Products
<i>Krista Farmer</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Charles Ferini	Undergrad Student	Feedstock Development & Production

<i>Daryan Godfrey</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Leslie Gunatilaka	Key Collaborator	Post-Harvest Logistics & Co-Products
Wolfgang Grunberg	Professional	ALL AREAS
<i>Matthew Harmon</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Danielle Hoare	Graduate Student	Feedstock Development & Production
<i>Stephanie Honeker</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Arisbeth Ibarra Nieblas	Graduate Student Fellow	Education
Aaron Judkins	Undergrad Student	Feedstock Development & Production
<i>Pujan Kafle</i>	<i>Graduate Student</i>	<i>System Performance & Sustainability</i>
Matthew Katterman	Graduate Student Fellow	Education Feedstock Development & Production
<i>C. Kasia Kiela</i>	<i>Undergrad Student</i>	<i>ALL AREAS</i>
Corey Knox	Professional	Education
Jessica Ledesma	Undergrad Student	Feedstock Development & Production
<i>Ashton Leo</i>	<i>Graduate Student Fellow</i>	<i>Education</i>
<i>Taylor Levy</i>	<i>Intern</i>	<i>Extension & Outreach</i>
Myles Lewis	Professional	Feedstock Development & Production
Manping Liu	Professional	Post-Harvest Logistics & Co-Products
Patrick Lohr	Graduate Student	Feedstock Development & Production
<i>Gerardo Lopez</i>	<i>Key Collaborator</i>	<i>Extension & Outreach</i>
<i>Jasmine Lopez</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
Raina Maier	Key Collaborator	Feedstock Development & Production
Hadiqa Maqsood	Graduate Student	Feedstock Development & Production
<i>Celestina Martinez</i>	<i>Intern</i>	<i>Extension & Outreach</i>
William McCloskey	Key Collaborator	Feedstock Development & Production
<i>Wenzhe Mi</i>	<i>Intern</i>	<i>Feedstock Development & Production</i>
<i>Istvan Molnar</i>	<i>Key Collaborator</i>	<i>Education</i>
<i>Madison Montes</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Leobardo Moreno	Undergrad Student	Feedstock Development & Production
Madison Morris	Undergrad Student	Feedstock Development & Production
Julie Neilson	Professional	Feedstock Development & Production
<i>Andrew Nelson</i>	<i>Post-doc</i>	<i>Feedstock Development & Production</i>
Kim Ogden	Key Collaborator	ALL AREAS
Huitzilin Ortiz	Graduate Student Fellow	Education
Lia Ossanna	Professional	Feedstock Development & Production
<i>Alexandra Peck</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Bryan Pastor	Professional	Feedstock Development & Production
<i>Duke Pauli</i>	<i>Key Collaborator</i>	<i>Feedstock Development & Production</i>
Alexandra Peck	Undergrad Student	Feedstock Development & Production
Livvi Pearson	Undergrad Student	Feedstock Development & Production
<i>Shaira Perez</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
<i>Sam Pernu</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Tenzin Phakdon	Graduate Student Fellow	Education
Sarocho Pradyawong	Post-doc	Feedstock Development & Production
Dennis T. Ray	Key Collaborator	Feedstock Development & Production
<i>Jaspreet Rekhi</i>	<i>Professional</i>	<i>Post-Harvest Logistics & Co-Products</i>
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
Stephanie Sikora	Professional	Education
Andrew Smith	Graduate Student	Feedstock Development & Production
<i>Ana Lucia Soto</i>	<i>Undergrad Student Intern</i>	<i>Feedstock Development & Production</i>
Seth Steichen	Graduate Student Fellow	Education
<i>Ou Sun</i>	<i>Graduate Student</i>	<i>System Performance & Sustainability</i>
Trent Teegerstrom	Key Collaborator	Extension & Outreach System Performance & Sustainability
Valerie Teetor	Professional	Feedstock Development & Production
<i>Mira Theilmann</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
<i>Christine Toering</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
<i>Gianni Velasco</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Peter Waller	Key Collaborator	Feedstock Development & Production
<i>Quinn Waltz</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
<i>John Willmon</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Ya-ming Xu	Post-doc	Post-Harvest Logistics & Co-Products
Ali Yaylali	Graduate Student Fellow	Education
Stevi Zozaya	Undergrad Student	Extension & Outreach
Daniel Zuniga-Vazquez	Graduate Student	Post-Harvest Logistics & Co-Products System Performance & Sustainability
USDA Agriculture Research Service – US Arid Lands Research Center, Maricopa AZ		
Hussein Abdel-Haleem	Key Collaborator	Feedstock Development & Production
<i>Adrianna Chambers</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
<i>Amber Dearstyne</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Tristan Dunton	Professional	Feedstock Development & Production
Harmony Glover	Undergrad Student	Feedstock Development & Production
<i>Greg Leake</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
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		
<i>Milagro Adom</i>	<i>Student (SEED)</i>	<i>Feedstock Development & Production</i>
<i>Sheyla Aucar</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
<i>Matthew Canonizado</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
<i>George Chong</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
Chen Dong	Professional	Feedstock Development & Production
Niu Dong	Professional	Feedstock Development & Production
Trinh Huynh	Professional	Feedstock Development & Production
Colleen McMahan	Key Collaborator	Feedstock Development & Production
Grisel Ponciano	Professional	Feedstock Development & Production
Dante Placido	Post-doc	Feedstock Development & Production
Mariano Resendiz	Professional	Feedstock Development & Production

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

Total Active Key Collaborators: **22**

Total Active Professional Staff: **38**

Total Active Postdoctoral Researchers: **6**

*Total Active Graduate Students: **31***

*Total Active Undergraduate Students: **32***

*Total Active Fellows: **11***

*Total Active /Interns: **0***

*Total Past Participants (no longer active): **75***

COLLABORATIONS AND OTHER CONTACTS

Collaborations:

<i>Academic Institutions:</i>	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 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 Soil, Water and Environmental Sciences - Dept. of Systems and Industrial Engineering - Institute of Energy Solutions - Natural Products Center - School of Natural Resources and the Environment - School of Plant Sciences University of New Mexico – Gallup - Dept. of Mathematics, Physical and Natural Science
<i>Nonprofits:</i>	
<i>Industrial or Commercial Firms:</i>	BASF Bridgestone Americas, Inc. Central Arizona Project (CAP) FMC Guar Resources Syngenta
<i>Federal Government</i>	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
<i>State or Local Governments:</i>	Arizona Department of Agriculture, Environmental Services Division
<i>Tribal Governments:</i>	
<i>Schools or School Systems:</i>	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
<i>Other Organizations (foreign or domestic):</i>	

Other Contacts:

<i>Contacts with others within recipient's organization (interdepartmental or interdisciplinary collaborations):</i>	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
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<i>Contacts with others outside the organization:</i>	Denver Museum of Nature and Science, Denver Colorado Central Arizona College
<i>Contacts with others outside the United States or with an international organization:</i>	

APPENDICES

APPENDIX 1. SBAR PROJECT BUDGET GUIDELINES

Documents Included

1. **SBAR Project Budget Guidelines** – Final SBAR guidelines for budget planning, allocation and spend-down. (2pgs)



Sustainable Bioeconomy for Arid Regions (SBAR) Project Budget Guidelines

1. Why it Matters and Purpose of this Document

Initially when a new project is proposed, a project narrative and budget are developed and evaluated/approved by the Funder (if awarded). Once the funding is received, the Principle Investigator's responsibility includes overall budget management to ensure the project achieves the defined objectives. Deliberate and consistent budget management is crucial for project success. Budget management guidelines clarify the intent behind budget decisions regarding resource allocation across the project components, and how the Principle Investigator and Project Director will manage the financial resources available.

Because the SBAR Project works from a large budget (\$14.8M) over multiple years and has many investigators contributing to the whole, these budget guidelines have been created to document the budget allocation process and may be used as a reference as budget decisions are made.

2. Determining Budget Allocations

Initial budget allocations (Years 1-2) were distributed based on the original budget per investigator. All future budget allocations (Years 3-5) may or may not have adjustments, as determined by the Leadership Team and External Advisory Board, and outlined here.

Budget allocations per investigator are dependent on achieving targets, deliverables, timelines, and amount of unspent funds across the project. Quarterly Reports should be an accurate representation of work and reflect the work being done on the project to meet deliverables annually. An annual meeting (Retreat) will be held each year to highlight and comprehensively evaluate progress made toward project goals.

Budget allocations per investigator will be dependent and contingent upon the results of a review of completed SBAR work, and documented progress toward meeting objectives outlined in the annual Scope of Work per investigator. Once prior work has been fully submitted and approved, future funds will be distributed annually after receipt, review and approval of the next year's annual Scope of Work.

Typically, allocations will be distributed to Co-PIs in late August/early September for the next 12 months. Project funds allocated must meet all of the following 3 criteria:

- Funds must be used solely for SBAR activities;
- Be directly and clearly tied to distinct activities and deliverables identified in annual Scopes of Work (per investigator);
- Be properly tracked during the year.

3. Unspent Funds

Co-PIs will be given an opportunity to explain and justify any anticipated unspent (carryover) funds on an annual basis. This opportunity is provided in an effort to proactively manage the larger budget and reallocate available resources for possible add-on and complementary work that will further the SBAR goals.

At no time is there a guarantee that Co-PIs will be allowed to carry unspent funds from one project year to the next.

4. Funding New Activities

Planned budget allocations will be reviewed annually by the University of Arizona Principle Investigator, and the Project Director to determine where unspent funds may be available for reallocation within the project components. Once an available amount is determined, every Co-PI will be given an opportunity to submit proposals for funding in the next project year. Proposals may include new activities not part of the original proposal (submitted in 2017).

The SBAR Project LEAD Team will review and rank the proposals submitted, and the annotated list will be provided to the SBAR External Advisory Board for consideration. During an Executive Session, the SBAR External Advisory Board will evaluate and prioritize the proposals for reallocation of available funding. Once a final ranking of “new” proposed activities is determined and final approval is obtained from the funder (if required), a final decision and notification will be made to all Co-PIs.

Approved new activities (and associated budgets) will be included in the following year’s allocations.

5. Non-Budgeted Expenditures

Although certain expenditures may be deemed “allowable costs” by the Funder, the University of Arizona Principle Investigator maintains final authority in decisions related to budget expenditures that did not appear in the original proposal (submitted in 2017).

If specific expenditures were not included in the original proposal but are considered “necessary for achieving project deliverables”, then a Co-PI may submit a request for reallocating funding within their own annually allocated budget when they submit their year-end spend down plans. However, food and meal costs will NOT be considered if they were not included and approved in the original proposal budget.

6. Dispute Resolution

In the event that there is a dispute on budget allocation that cannot be resolved by the Co-PI(s) involved through agreement with the University of Arizona Principle Investigator, the matter will be taken under consideration by the SBAR LEAD Team members. A majority vote by the SBAR LEAD Team will conclude the issue.

APPENDIX 2. SBAR GROWER EXTENSION NEWSLETTER

Documents Included

1. **SBAR Grower Extension Newsletter, December 2019, Volume 1, Issue 1** – Overview and update of on-going SBAR research in New Mexico and Arizona. (2pgs)



SUSTAINABLE BIOECONOMY
FOR ARID REGIONS

Grower Extension Newsletter

December 2019; Volume 1, Issue 1

ANNOUNCEMENTS

- > **Whole Farm Analysis Tool**
Available March 2020
Contact: Trent Teegerstrom
- > **SBAR "Arid Regions" Educator Training**
Online workshops start June 2020
Contact: Torran Anderson
- > **AZ Guayule Field Trials**
Contact: Blase Evancho
- > **NM Guar Field Trials**
Contact: John Idowu
- > **FFA Train the Trainer**
Workshops February 2020
Contact: Paul Gutierrez
- > **Online Education Resources**
Arid Regions Lessons available in January 2020
sbar.arizona.edu/education
- > **Congratulations Melissa Wilburn**
Middle School Science Teacher of the Year Honorable Mention!



SBAR Fellow Arisbeth Ibarra Nieblas with SBAR Educator Melissa Wilburn at Quail Run Elementary in Tucson, AZ

SAVE THE DATE

March 10, 2020

Alternative Crops Conference
Portales, NM

sbar.arizona.edu/resources/events

GUAR IN NEW MEXICO

SBAR has been moving ahead with research and extension focused on guar and guayule. Research activities include agronomic optimization of both crops for different agro-ecosystems in Arizona and New Mexico. Guayule research is more focused towards Arizona while guar research is more directed toward New Mexico.

Multiple demonstration trials for both crops have been set up in New Mexico and Arizona, testing different aspects such as irrigation, fertility and cultivar evaluations.

Guar demonstration trials are currently being hosted in New Mexico. In 2018, trials testing the effect of different rates of phosphorus and inoculum application on growth and yield of guar were conducted at Los Lunas Ag. Science Center and Clovis Ag. Science Center. The result of this trial showed that the inoculum applied was not effective as there were no significant differences in guar yield between inoculated and uninoculated treatments. Additionally, phosphorus rates did not affect guar yield. No nodules on guar roots were evident at either site (Los Lunas and Clovis, NM). Guar bean yields were low, averaging 1000 lb./ac in Clovis and 800 lb./ac in Los Lunas. We suspected that the guar may not be getting enough nitrogen given the problems with nodulation in some soils.

Therefore, in 2019, the study was changed to include testing different rates of nitrogen and phosphorus together at four sites in NM. These sites were Leyendecker Plant Science Center, Los Lunas Ag. Science Center, Clovis Ag. Science Center, and Tucumcari Ag. Science Center. These trials have been harvested from the field and we are still processing the different treatments to evaluate the final yields. Results will be shared as soon as they are available.



< Guar trial in
Tucumcari, NM,
August 2019



> Guar trial in Los
Lunas, NM,
August 2019

We continue to share information about SBAR at agricultural meetings and events in both New Mexico and Arizona, we are always happy to visit with you if you have any questions.

~ John Idowu, Extension Agronomist, New Mexico State University

The SBAR Whole Farm Analysis Tool for Evaluating the Adoption of Guayule and Guar into Your Current Operation

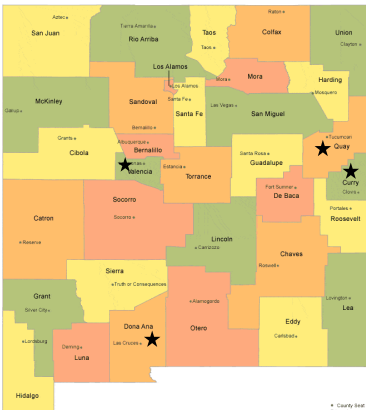
To effectively evaluate the potential adoption of these two crops within your existing operation, the SBAR/Sustainability Economic Team is adding the final touches on a Whole Farm Analysis Tool they developed which will allow producers to evaluate the net returns to the operation given varying levels of acreage adoption, crop mixes and changes in production inputs, thereby allowing for a more informed decision about the economics and overall fit of the crops into their operation.

Available March 2020. Contact: Trent Teegerstrom (520) 621-6245 or tteegers@email.arizona.edu

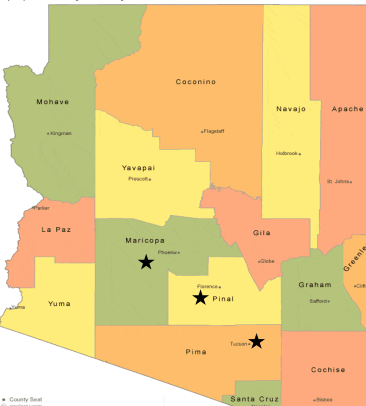


SBAR presents at US Congressional Research Exhibit in Washington DC

★ Guar field trials in New Mexico



★ Guayule plots in Arizona



Guayule in Arizona

With the close of the year we have the opportunity to review the field events of 2019 and preview the new experiments for 2020 that make working with guayule and the SBAR Center of Excellence such an exciting endeavor. With our focus on guayule in Arizona, and access to work with Bridgestone, our major industry backing partner, we held a field day for farmers and agriculture professionals to tour the Bridgestone Guayule Research farm and rubber extraction facilities. This event was collaboratively hosted by Bridgestone, University of Arizona Cooperative Extension and SBAR to provide an in depth look at the experiments and advancements that are being made through research associated with this partnership. Attendees had the opportunity to hear about Bridgestone's long term goals, their agronomic research, SBAR weed management and irrigation research as well as Cooperative Extension research in insect management. Results from the trials exhibited at the field day have led us to some new experiments to better manage this experimental production system.

Our irrigation trial of applying water at 50%, 75%, 100% and 150% of predicted irrigation water requirement left us with questions about the true irrigation water threshold of this production system. This led us to a new experiment where we further reduced the irrigation water inputs and changed the way in which we are irrigating by applying water only when the plant is actively growing. We hope this experiment will bring us closer to the point where economic yield and irrigation water conservation meet.

We will complete new weed control trials in 2020. While we have an early seedling weed control program that is very effective, the focus of the new trials will be to collect data for pre-emergent herbicides specifically on sandy soils. We will also look at herbicides for weed control in stands that have been established but have not yet closed their canopy.

These new trials will be valuable as we travel the road toward commercial production of guayule. We look forward to sharing more experimental results in 2020.

~ Blase Evancho, Extension Agent, University of Arizona



Dr. David Dierig of Bridgestone discusses Guayule production.

Contact Our Team

Education & Outreach

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Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867



APPENDIX 3. MEETING AGENDAS

Documents Included

1. **The 9th Annual Central Arizona Farmer Field Day** – Agenda for one-day field event hosted at the Maricopa Agricultural Center (MAC) targeted to Arizona producers. 8 October 2019. (1p)

THE 9TH ANNUAL CENTRAL ARIZONA FARMER FIELD DAY

Tuesday, October 8, 2019 - 7:45 AM to 1:00 PM

Maricopa Agricultural Center (MAC) - 37860 W. Smith Enke Road, Maricopa, AZ 85138

(5) AZ Department of Ag CEUs have been approved

7:45 – 8:00	Multipurpose Room	Registration
	Dr. Pedro Andrade Sanchez	Demonstration of Variable-Rate Chemical Application Technology
	Dr. Peter Ellsworth	Lygus, Whitefly, and Beneficial Insect Management in Cotton
8:00 – 12:00	Dr. Bill McCloskey	Guayule Weed Control Research Project
Outdoor Tour Research Farm	Dr. Ayman Mostafa	Pest Management of Forage Crops
	Dr. Randy Norton	Heat Stress Impacts on Cotton Variety Performance & Management of Diseases in Arizona Cotton Production Systems
	Dr. Mike Ottman	Sorghum Hybrid Evaluation
	Dr. Charles Sanchez	Gravity Micro-Irrigation for Field Crops
12:00 - 12:30	Dr. Paul Brown	Review of Growing Season Weather & Water Supply Update
12:30 – 1:00	Lunch and Discussion of Crop and Pest Management	

Questions? Please contact

Ayman Mostafa

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Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Jeffrey C. Silvertooth, Associate Dean & Director, Extension & Economic Development, Division of Agriculture, Life and Veterinary Sciences, and Cooperative Extension, The University of Arizona.

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APPENDIX 4. OUTREACH EVENTS

Documents Included

1. **Cooperative Extension Day** – Flyer announcement for the one-day event hosted at the Maricopa Agricultural Center (MAC) targeted to Arizona families. 12 October 2019. (1p)



THE UNIVERSITY OF ARIZONA

Cooperative Extension

Pinal County

University of Arizona, Cooperative Extension, Pinal
820 East Cottonwood Lane, #C, Casa Grande, AZ 85122
(520) 836-5221, phone / extension.arizona.edu/pinal

Free!!!
ELGG!!!

FAMILY FUN DAY!!!

Join us for this fun, family event
free to the community...

WE WILL HAVE...

- A Bounce House
- Balloons
- Face Painting
- Food
- Fun Activities
- Games
- Music
- Prizes
- Raffles



Cooperative Extension Day

Saturday, October 12, 2019—9:00 am to 12:00 pm
820 East Cottonwood Lane, Casa Grande, Arizona 85122

ACTIVITIES INCLUDE:

- Improving your Financial Health
- Learning about sources of food & fiber
- Learning how to prevent diabetes
- Make a water cycle bracelet
- Make your own healthy snack
- Master Gardening Demonstration
- Oral Health Screenings
- Physical Activity
- Vision & Hearing Screenings
- And much, much more!



PROGRAMS FEATURING THE FUN FAMILY ACTIVITIES:

- 4-H Youth Development
- Ag Ventures
- AmeriCorps
- AZ Health Zone
- Child Care Health Consultation
- Developmental & Sensory Screening
- EFNEP
- Field Crops Systems
- Financial Literacy & Parenting
- Master Gardening/Garden & Landscape
- Pinal First Smiles
- Prevent Type 2 Diabetes
- Project WET
- Strengthening Families
- And many others!

SUPPORTED BY

FIRST THINGS FIRST

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