



SUSTAINABLE BIOECONOMY FOR ARID REGIONS (SBAR)

Summary Report – Quarter 4, 2020

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

USDA Cover Page

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ACCOMPLISHMENTS

October 2020 – December 2020

INTRODUCTION AND MANAGEMENT

General Overview: Organization

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

A comprehensive project evaluation plan, approved in July 2018, continues to effectively capture 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 next scheduled thorough review and update will be in August 2021.

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

Obtaining signed non-disclosure agreements (NDA) to ensure confidentiality of research data, information, and conclusions for the duration of the project was somewhat successful. 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. No further concerted effort will be made to acquire signed NDAs.

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

The Advisory Board met virtually during the previous quarter on 18 November 2020, where members were able to ask direct questions and work with the team to determine the best implementation strategy for ongoing research needs during a national pandemic. Future Advisory Meetings will be hosted in January, March and May of 2021 to ensure that the research and outcomes remain on track.

Budget and Financial Management

Budget management activities continued to work effectively, and all project expenditures are on track. Rogstad continued to maintain sub-award agreements and sub-award 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.

Component Working Group Meetings

All five SBAR component working groups continued to participate in scheduled online meetings to ensure forward momentum on all project tasks. Smaller focus group meetings were scheduled and facilitated as necessary, including budget meetings and partnership development meetings. During this reporting period, the virtual meeting space (via Zoom) was utilized 52 times for over 48.1 hours. As with the previous quarter COVID-19 shifted most in-person meetings to virtual platforms, which resulted in more time in virtual meetings. The total number of participants was slightly fewer than previous quarters for all working group meetings (n=509), which is likely the result of university and partner institution's temporary closures.



Photo 1. Screenshot of a Zoom working session for the Education Component.

LEADS Team Meetings

The component leaders and co-leaders (LEADS) continued to meet with Ogden and Rogstad during established fortnightly meetings held via SBAR's dedicated Zoom online meeting space.

The LEADS 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.

SBAR Annual Retreat

As in previous years, the SBAR Annual Retreat is being planned for hosting at the University of Arizona in Tucson from 12-13 August 2021. The Retreat will include updates from industry partners and visionaries, research highlights 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 oral/poster presentations. We are tentatively planning for Component specific sessions during the retreat. Preparation and pre-planning are 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 enable quick dissemination of pertinent and critical information. Rogstad also fields questions and liaises among project researchers, Advisors, partners, and students.

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

Website, Social Media and Digital Tools

The SBAR-specific website (www.sbar.arizona.edu) continues to be regularly updated and maintained, serving as the digital “face” of the SBAR Center. Updates this quarter included project highlights that showcased new work, and major updates and revisions for the research component pages. The Extension & Outreach pages – including the Grower-focused pages and the Youth Development page – are currently under revision.

The SBAR webpage was visited by people in 39 different states of the USA during this reporting period (Table 2). Since inception, the website has been viewed by people in 49 states (all but Vermont), which is an indication of wide interest in the ongoing research as well as the broad dissemination of information implemented by project partners.

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

State	Time Period					
	Jul – Dec 2018	Jan – Dec 2019	Jan – Mar 2020	Apr – Jun 2020	Jul – Sep 2020	Oct – Dec 2020
Alabama				X		

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

State	Time Period					
	Jul – Dec 2018	Jan – Dec 2019	Jan – Mar 2020	Apr – Jun 2020	Jul – Sep 2020	Oct – Dec 2020
Virginia		X	X	X	X	X
Washington	X	X	X	X	X	X
West Virginia		X				
Wisconsin		X		X		
Wyoming		X	X	X	X	X
Total	15	41	40	41	42	39

There were 1,129 unique sessions from October - December 2020, which is an increase from the previous quarter. Page views occurred in 37 different countries (top three: USA, Thailand, and Austria), including 3 countries that have not visited the website previously (Denmark, Iraq, and Libya). Visitors from the USA account for 86.9% of site visits during this reporting period. This quarter showed a high interest from Thailand, India, Austria, France, and Netherlands, which accounted for another 6% of site visits overall. Approximately 8% of the sessions are returning visitors to the site, while 92% are new/first-time visitors.

There have been 10,789 unique website sessions since July 2018. Since activation, the website has had visitors from 6 continents and 85 different countries around the world (Table 3). The highest visited website pages during this period included those that describe the research conducted by the characterizations and co-products team, those that describe our team and partnerships, those that describe the feedstock development research, and those associated with digital lessons and educational resources. Other highly visited pages included special award highlights and those that describe the research conducted by the system performance and sustainability team. The website will continue to be updated regularly as the project unfolds.

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

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

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

Country	Time Period					
	Jul – Dec 2018	Jan – Dec 2019	Jan – Mar 2020	Apr – Jun 2020	Jul – Sep 2020	Oct – Dec 2020
Portugal		X				
Puerto Rico					X	
Qatar		X	X		X	
Romania			X			
Russia		X				
Saudi Arabia		X	X			X
Serbia				X	X	X
Singapore		X			X	X
South Africa		X				
South Korea		X	X	X	X	X
Spain		X				X
Sri Lanka		X				
Sweden		X			X	
Switzerland			X	X		
Taiwan		X				
Thailand	X	X	X			X
Tunisia					X	
Turkey	X	X	X	X	X	X
Uganda				X		
Ukraine		X				
United Arab Emirates		X				
United Kingdom	X	X	X		X	X
United States	X	X	X	X	X	X
Vietnam		X				X
Zambia		X				
Total	22	60	36	32	39	37

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 to address specific topics. The UA leads 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 the UA and monthly at New Mexico State University. These briefings provide an opportunity for open communication regarding on-going experiments, issues/challenges, and results for both guayule and guar research. Quarterly summary reports provide an opportunity to discuss relevant research topics and questions that may need further exploration.

Issues/Risks:

Abdel-Haleem: Even with COVID-19 pandemic situation and USDA policies of minimum essential operations and maximum teleworking, it is expected to meet the 2021 milestones.

Angadi: The COVID-19 pandemic has affected our research program. I could not replace graduate student, research scientist, and temporary technicians for quite some time. Only essential part of my field projects was completed. Laboratory work is delayed. Processing field samples, data collection and data processing are delayed. With help from other programs, we harvested trials and are making some progress in processing.

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

Grover: The COVID-19 lockdown has somewhat impacted the activities with restricted face-to-face interactions.

McCloskey: There are many challenges when planting small fields for guayule research as was shown in spring and fall 2020 plantings. There is insect predation especially when planting close to older guayule or alfalfa that provides source of plant eating insects. In addition, in fall 2020 we suffered severe plant loss due to birds destroying the plants. We don't know if they were feeding on insects on the plants or eating the plants (which seems unlikely). I am at wits end trying to figure out how to obtain successful guayule establishment. At MAC in spring 2021 we will plant only the center 8 rows of each 12-row border so that we can maintain a dry strip where MAC's broadcast sprayer can drive so that we can spray topical insecticides in addition to planting seed treated with insecticide. In addition, we will avoid planting near alfalfa or other perennial crops or the two washes that run through the farm where perennial vegetation exists, and we will plant in two locations on the farm in an attempt to obtain one successful planting. I do not have a strategy devised yet for the spring planting at Bridgestone-Eloy but will work with Sam on such a plan in the next two months.

McMahan: The USDA-ARS-WRRC location was closed, except for essential work, in response to the COVID-19 pandemic on March 17, 2020. In 4Q20, due to the limited lab access, some genotype/phenotype evaluations did not take place (previously reported). Plants were

maintained and grew in cultures and moved to greenhouse. Year 4 deliverables are still on track.

Neilson/Maier: The DNA extractions on soils sampled in 2018 and 2019 are still under progress by K. Brown. 187 of the 216 extractions are now complete. COVID restrictions have limited our ability to work in the lab. The absence of in-person classes for children (of students) have limited availability to work in-person. K. Brown is using the time to complete the literature reviews described.

The bioinformatics analysis of the 2018 and 2019 soil samples from the guayule irrigation field trials will be completed when the DNA extractions and amplicon sequencing are completed. Amplicon sequencing of Yr2 and Yr3 samples was attempted in December 2020, however poor results were delivered by the UA Genomics Core. The work is being repeated now, and we don't anticipate further delays.

Ogden: We are still being affected by the Coronavirus disease (COVID-19). The situation was better but turned worse at the end of the year. We have a better adjustment to work efficiently under the pandemic but still got affected by the situation. We switched graduate students for AquaCrop, but progress is slow starting over to train a new student. Dr. Waller is assisting. His student is working with AquaCrop for guar while we work on guayule and we are trouble-shooting together.

Ray: Due to faulty emitters, there was a set-back in the nitrogen study (Objective 4.2). The test is restarting.

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	Recover live plants from transformed calli (SEP3, FT, LEAFY)	Confirmed transformation for <i>in vitro</i> plants – 6 lines SEP3	30 Jun 21
		Confirmed transformation for <i>in vitro</i> plants – 6 lines FT	30 Jun 21
		Confirmed transformation for <i>in vitro</i> plants – 6 lines LEAFY	30 Jun 21
3 McMah	Determine effect of transgenes on rubber content by ASE (tissue culture)	% rubber data obtained for each construct line	30 Jun 21
4 McMah	Transfer plants to greenhouse/growth chamber for flowering phenotype	Transfer at least 2 lines to greenhouse	31 Dec 20

5 Ray	Evaluate growth and rubber/resin content in guayule germplasm lines	Rubber/resin content determined in 21 guayule germplasm lines	30 Apr 21
6 Ray	Compare root growth/architecture and water use in direct-seeded and transplant-established guayule	Compare root growth/top growth/water use	31 Mar 21

Evaluate Germplasm Lines (Variety Trials):

Nothing new to report at this time. A full analysis and interpretation of data will be coming soon with all the trials together.

Recover Live Plants from Transformed Calli – SEP3, FT, and LEAFY Genes:

Our project seeks to enhance natural rubber content in guayule by downregulation of flowering. Previously, five target genes (*APETALA1*, *SEPATTALA3*, *FLOWERING TERMINUS*, *LEAFY* and *pND6-AP1-SEP3 (pAS)*), all transcription factors related to flowering, were used to transform guayule cultivar G7-11. As of 4Q20, all surviving calli/plants harboring *APELATA1*, and *pAS* failed to survive. We suspect the *AP1* phenotype may be lethal.

In 4Q20, we concentrated on continued recovery of transformed plants from remaining calli, and moving tissue culture plants to the greenhouse for phenotype studies. *SEP3* has been the most successful. We have full plants from 10 transformation events (6 PCR confirmed), and have begun the move to the greenhouse. For the *FT2* and *LEAFY* constructs, we have so far recovered plants from 2 transformation events. We prefer 3-6, but some calli continue to grow, so it is possible we will recover additional event(s).

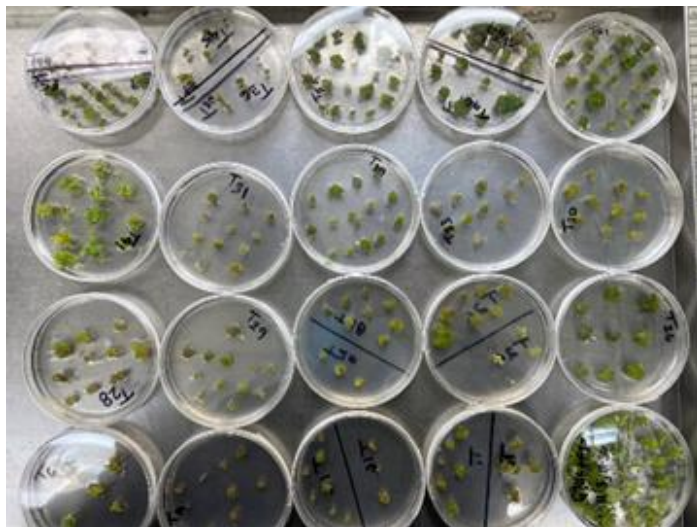


Figure 1. Calli growing under selection pressure.

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:

In November 2020 the first set of tissue culture plants (*SEP3* H, I, J with *pND6* and G711 controls) were moved to soil and placed in the greenhouse. We experienced moderate losses of

plants but have sufficient material for characterization (i.e. we start with 6 but need 3 from each genotype). They will move to the growth chamber (warm days, cool nights) for 30 days starting Feb 1, where phenotype data will be collected. The second set of tissue culture plants (SEP3i A, B, C, E, with pND6 and G711 controls) were moved to soil in December 2020. The SEP3i transformations were the most successful (10 lines) so will be characterized in series (space limitations).

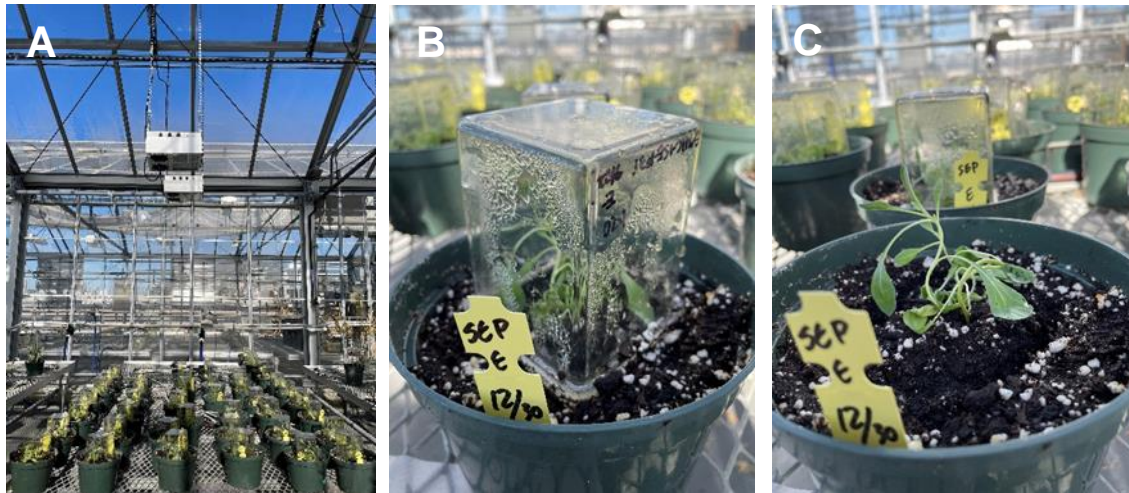


Figure 2. Transformed guayule (SEP3i) plants shortly after transfer to soil. A) full set; B) single plant with cover; and C) single plant without cover.



Figure 3. SEP3i plant in greenhouse ~1 month after transfer from tissue culture.

Growth and Rubber/Resin Content in Guayule Germplasm Lines:

Bridgestone transplanted guayule AZ-2, AZ-6, Cal-3, Mex-1, and Mex-2 at Campbell Ave Farm (Tucson) on 1 October and replanted missing/non-surviving plants on 20 October. Six plants per row of each line. Twenty-four plants per plot. Twelve-inch spacing between plants and no space between plots, 24 plants in each plot (6 plants/row/plot).

	Rep I	Rep II	Rep III	Rep IV																
Row 6	Guard Row – AZ-6 (Sel 1)																			
Row 5	1	2	3	4	5	1	5	4	2	3	3	5	4	1	2	5	2	1	4	3
Row 4	1	2	3	4	5	1	5	4	2	3	3	5	4	1	2	5	2	1	4	3
Row 3	1	2	3	4	5	1	5	4	2	3	3	5	4	1	2	5	2	1	4	3
Row 2	1	2	3	4	5	1	5	4	2	3	3	5	4	1	2	5	2	1	4	3
Row 1	Guard Row– AZ-2																			
	1 = AZ-6				2 = AZ-2				3 = Cal-3				4 = Mex-1				5 = Mex-2			

Figure 4. Field map of guayule plants transplanted on 1 October at Campbell Avenue Farm, Tucson, Arizona.

Root Growth/Architecture Compared to Water Use in Direct Seed and Transplant-Established:
 Guayule planted in the greenhouse on 12 October 2020.

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

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

		(HTP) parameters: vegetation indexes and reflectance	
		Summary report completed	30 Jun 22
3 Angadi	Guar remote sensing	Seasonal multispectral data from deficit irrigation study	31 Mar 20

Phenotypic characterization – Guayule:

Evaluation of 48 USDA guayule accessions grown under normal Arizona conditions. A data set was collected from Maricopa site and are organized toward summarizing and publishing in collaboration with Eloy and Tucson teams.

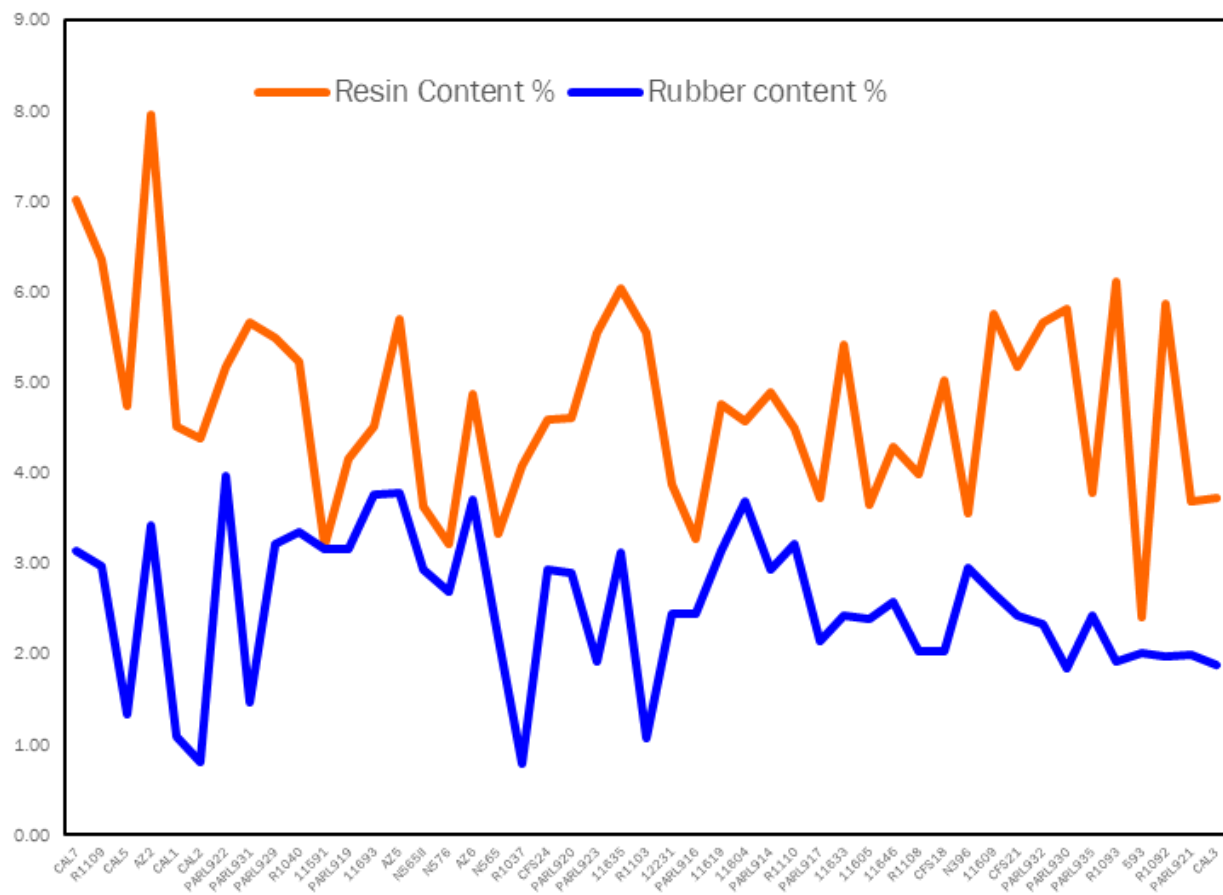


Figure 5. Variation in rubber and resin contents among USDA guayule genotypes growing under normal conditions, Maricopa, Arizona.

Phenotypic characterization – Guayule Under Stress Conditions:

An experiment with 60 guayule genotypes, including genotypes are first time to be tested, and 6 common checks is planted at Maricopa, AZ to study responses of guayule genotypes growing under stress and none stress conditions, and the interactions of irrigation levels by genotypes interactions. Differential irrigation schedules were started at stress and no stress treatments. At

both trials, plots are maintained by hand weeding as needed. At November, one-year plants were harvested, and fresh and dry weights were determined.

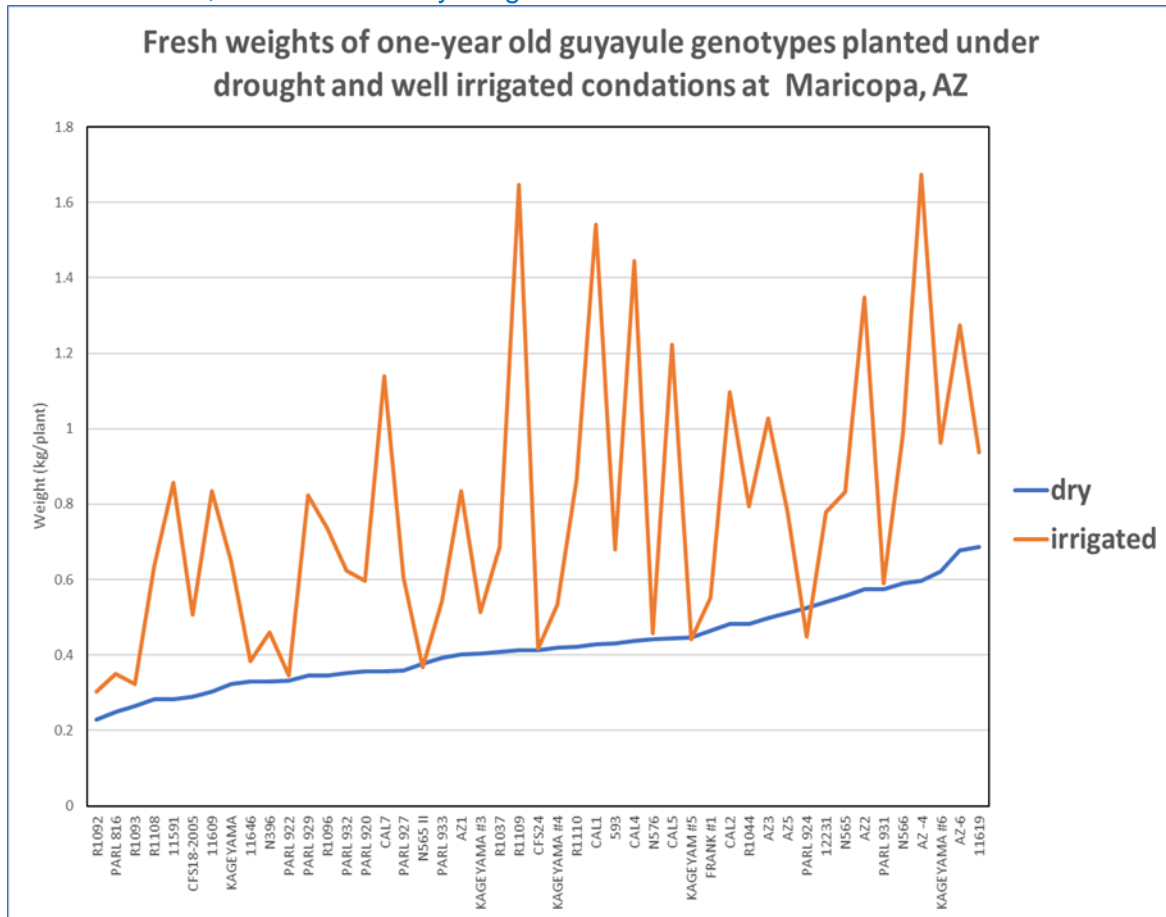


Figure 6. Fresh weight of one-year-old guayule planted under drought and well-irrigated conditions, Maricopa, Arizona.

Data showed that dry and fresh weights are affected by genotypes as well irrigation levels (stress conditions). Drought stress condition reduced fresh/dry weights, the reduction rates are varied among genotypes, indicating that there are genetic bases for the variation and the responses of drought stress among guayule genotypes. Several genotypes, such as PARL 922, N565 II, and CFS24, had similar weight under both conditions (drought and no drought). When confirmed with 2-year-old data (be harvested at November 2021) those genotypes could be a good candidate for drought stress tolerance breeding and studies.

Due to global COVID-19 pandemic situation and USDA policies of minimum essential operations at USDA-ALARC facility and maximum teleworking, dried plants are kept in the -18C waiting for resin and rubber estimation.

Guar Remote Sensing:

This task is complete.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Evaluate guar germplasm in New Mexico high plains environment	Screen guar germplasm for adoptability in High Plains	31 Mar 21
		Assess available guar cultivars at Clovis, NM	31 Jul 21
2 Grover	Evaluate guar germplasm lines for field performance	Thresh remaining Yr3 samples for seed collection	31 Oct 20
3 Ray	Evaluate seed from plants surviving root rot inoculation	New germplasm lines screened for the first time	31 Aug 21
4 Ray	Guayule salt tolerance trials	Screen new germplasm lines with most tolerance	31 Jul 21
		Surviving plants transplanted to field to increase seed	30 Apr 21
		Seed from surviving plants collected and planted for 2 nd round of selection	31 Aug 21
5 Ray	Guar yield trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM	Yield trials planted in 3 locations	30 Jun 20
		Yield trials harvested; yields compared	31 Dec 20

Guar Germplasm in New Mexico:

We completed first part of assessing temperature requirement for germination and early growth of current guar cultivars. The manuscript is published. Next part of assessing USDA germplasm for cooler soil conditions is delayed.

COVID restrictions and no graduate student on board affected this project. If situations improve, we will conduct this project next fall and winter.

Guar Germplasm Field Performance (threshing):

The study was harvested at Lyendecker Plant Science Center, Las Cruces, New Mexico, and plant samples collected for final seed yields. Threshing of the square meter harvested samples will be completed in the coming weeks with the thresher. Single plants were also collected and will be manually threshed for recording the observations on seed yield attributing characteristics.

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

No new data to report. Work on new screenings has stopped until new sources of the root rot fungus are obtained.

Guayule Salt Tolerance Trials:

Research continues; no new data to report.

Guar Yield Trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM:
Guar selections harvested 16-18 and 20 November 2020.



Photo 2. Dr. Dennis Ray assisting with hand-harvest of guar in Tucson, Arizona.



Photo 3. Guar seeds were separated from the seed pods by a thresher.

Table 4. 2020 guar selections harvested 16-18 and 20 November.

Guar Selections 2020				
Plot/selection number 2020	Original line 2018	Plot # 2018	Sel # 2019	Characteristics
106A	CMS x Lewis (Row 21)	CMS x Lewis	15	Non-branching
106B	CMS x Lewis (Row 21)	CMS x Lewis	15	Branching (Lewis-like) , early maturity, excellent pods/biomass ratio, glabrous, basal-branching
107	Santa Cruz	G30	5	Santa Cruz-type, glabrous, good pods/biomass ratio, branching
108A		Vol. HT. 6' single stalk		Non-branching, upright
108B		Vol. HT. 6' single stalk		Non-branching, too tall
109	TX-3292	G27	1	Non-branching
110	CMS x Lewis	CMS x Lewis	16	Lewis-like), early maturity, excellent pods/biomass ratio, glabrous, basal-branching
111A	G34 MS row 26	G34	12	Branching
111B	G34 MS row 26	G34	12	Non-branching

114	Surti	G16	18	Basal Branching, Early maturing, pubescent
115	G-05	G28	10	Basal Branching, Early maturing
116	Matador	Matador	20	Branching, mid maturity, few pods/biomass, pubescent
117A	Male-sterile (Row 18)	G33	11	Non-branching
117B	Male-sterile (Row 18)	G33	11	Basal-branching
118	G9B-49824	G9	3	Non-branching
119	G24A	G24	9	Basal Branching
120	G25A	G25	2	Branching
120A	G25A	G25	2	Branching
120B	G25A	G25	2	Non-branching
203	TX71-3292	G27	1	Basal-branching
204	COL NO K619	G6	4	
205	CMS x Lewis (Row 21)	CMS x Lewis	15	Branching (Lewis-like), early maturity, excellent pods/biomass ratio, glabrous, basal-branching
206	Male-sterile (Row 18)	G33	11	
207	TX78-3726	G29	9	Early maturity, excellent pods/biomass ratio
208	B-49824	G9	3	
209	WKP-88-43	G13	Plot 413	
210	G34 MS row 26	G34	12	
212	Male Sterile (Row 21)	G33	17	
213	CMS (S1) x Matador	CMS (S1) x Matador	13	
214	Santa Cruz	Santa Cruz	5	Glabrous, good pods/biomass ratio, branching, mid maturity
215	Surti	G16	8	Basal Branching, early maturing, pubescent
217	CMS x Lewis		16	
218	Composite cross	Composite cross	219 Composite	Bulk Composite
219	Composite cross	Composite cross	219 Composite single-stalk	Non-branching
Composite cross	Composite cross	Composite cross	Composite cross	Branching

Composite cross	Composite cross	Composite cross	Composite cross	Basal-branching
Composite cross	Composite cross	Composite cross	Composite cross	Non-branching
Composite cross	Composite cross	Composite cross	Composite cross	Basal-branching, short
Composite cross	Composite cross	Composite cross	Composite cross	Non-branching, short
Composite cross	Composite cross	Composite cross	Composite cross	Branching, small/short
Composite cross	Composite cross	Composite cross	Composite cross	Basal-branching, tall
Composite cross	Composite cross	Composite cross	Composite cross	Non-branching, tall

Guar variety trail harvested 5-6 November. Yields have been calculated (see below).

Table 5. 2020 Tucson Guar Yields: Comparisons for each pair using Student's *t*. Levels not connected by same letter are significantly different.

Level	Number	Mean kg/ha	
Lewis AZ	3	3520.1	A
Lewis TX	3	3439.3	AB
B-49824	3	3418.8	AB
EC 248A	3	3310.0	ABC
Kinman	3	3173.2	ABCD
NO 10521	3	3160.2	ABCD
TX 78-3726	3	3105.3	ABCD
B-49819	3	3076.2	ABCDE
PI 542608	3	3075.1	ABCDE
SANTA C RUZ	3	2994.3	ABCDEF
WKP-88-43	3	2986.7	ABCDEF
TX73-2731	3	2910.2	ABCDEF
PI 263406	3	2896.2	BCDEF
COL NO 36 PUNJAB	3	2796.0	CDEFG
NO 10949	3	2779.9	CDEFG
PLG 86	3	2777.7	CDEFG
B-49823	3	2760.5	CDEFG
TX71-3292	3	2708.8	CDEFG
PI 186477	3	2681.8	DEFG
G-05	3	2672.1	DEFG
COL NO K619	3	2670.0	DEFG
PLG 241	3	2475.0	EFG
PI 263698	3	2450.1	FG
IC-83 NO 3	3	2424.3	FG
SIRSA 56	3	2385.5	FG
PLG 482	3	2231.4	G
Matador	3	2200.2	G
SURTI	3	2181.9	G

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Conduct guar critical stage-based deficit irrigation trial	Report on growth stage-based irrigation management Present data at regional and national conferences	30 Nov 20 30 Nov 20
2 Dierig	Bi-monthly harvest from irrigation trials	Growth data over seasons from two locations	31 May 22
3 Dierig	Irrigation Timing Study	Plant replicated trial and begin treatments	31 Aug 21
4 Grover	Evaluate guar germplasm lines for field performance	Collect field data and harvest samples. Process lab data and complete data analysis. Generate report/publication from results obtained	30 Jun 21 30 Jun 21 31 Aug 21
5 Grover	Evaluate guar response for salinity tolerance	Screen 27 diverse guar lines under salinity stress Identify sources of salinity tolerance characterized by gene expression analysis. Summarize results	30 Jun 21 31 Aug 21 31 Dec 21
6 Grover	Evaluate guar response to moisture stress	Review, edit manuscript draft Revise, complete, submit manuscripts to journals	31 Dec 20 31 Mar 21
7 Grover	Evaluate guar response to planting density	Track and collect research data on guar density experiment Generate report/publication from results obtained	30 Jun 21 31 Aug 21
8 McClos	Conduct guayule herbicide tolerance study, at Eloy and Maricopa, AZ (Fall)	Collect data to support 24c SLN herbicide registrations – (a) post-directed herbicide; (b) herbicide application sequence for chemical weed control from seeding to 6mo old plants; (c) evaluate topical postemergence broadleaf herbicide	31 May 21
9 McClos	Conduct guayule herbicide tolerance studies, at Eloy and Maricopa, AZ (Spring)	Collect data to support 24c SLN herbicide registrations – (a) post-directed herbicide; (b) herbicide application sequence	31 Aug 21

		for chemical weed control from seeding to 6mo old plants; (c) evaluate topical, postemergence broadleaf herbicide	
10 McClos	Generate manuscripts and Extension bulletins	Research reports and manuscripts complete	31 Dec 20
		Extension bulletin and 24c SLN ADA application complete	31 Aug 21
11 Ogden	Development and testing of AquaCrop model	Growth model compared to field data	31 Dec 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 Ray	Direct-seeded vs. Transplant-established guayule	Compare root growth and top growth vs. water usage under varying conditions	31 Mar 21
15 Waller	Monitor TDR, infrared camera and flowmeter system	Provide data on guayule irrigation experiments	31 Aug 21
		Provide data set that can be used to refine the use of sensors for WINDS crop irrigation mgmt.	31 Aug 21
16 Waller	Integrate WINDS model with existing tools	Integrate new model with WINDS (winds.arizona.edu), and in-situ sensors	31 Aug 21
17 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	31 Aug 21
		Develop automated calibration system for WINDS	31 Aug 21

Guar Critical Stage-Based Deficit Irrigation Trial:

The third year of the trial was harvested from the field and samples were collected and put in storage, but COVID affected threshing and processing those samples. Data is currently being processed by a former graduate student. Time lapse videos were collected from four diverse treatments and will be edited for final outreach products.



Photo 4. Pre-irrigated (A) vs. rainfed (B) guar plots in Clovis, New Mexico.

Due to COVID budget cut, I am not able to replace Research Scientist position in my program. My effort to hire temporary lab tech has not been successful for the last three months. I am also not able to fill the graduate student position to work on guar. With the help from other programs and from Dr. John Idowu's program, I am slowly making progress in processing samples. I should have data from most trials of 2020 in a month. I am encouraging my former graduate student to write deficit irrigation manuscripts and get credit for hard work he has done.

Bi-Monthly Harvest from Irrigation Trials:

Nothing new to report.

Irrigation Timing Study:

This is a deficit irrigation study for guayule.

Treatments:

1. Full Irrigation: Irrigate as determined by the model developed as part of this project.
2. Stress for Harvest: Full irrigation for the first 18 months, then stop irrigation. Sample plants every two months to study if stress helps rubber and resin content before final harvest.
3. Half Irrigation: Irrigate every other irrigation as determined by the model.
4. Minimum Irrigation: Irrigate three times per year, approximately every growth stage (May/June, September, and February).
5. Minimum Year2: Year 1 irrigate as determined by the model, and Year 2 irrigate three times (February, May/June, September).
6. One Irrigation: One irrigation after establishment in the first year (Sept), one irrigation in year 2 (Apr).

Data and Results:

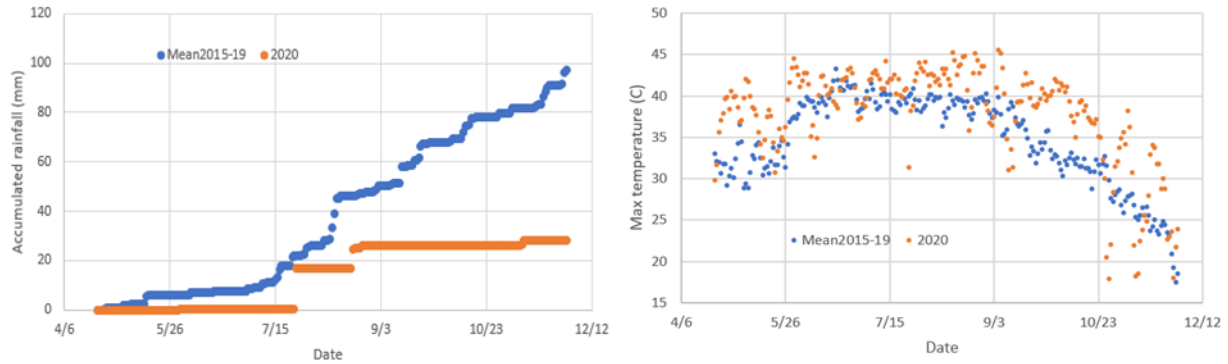


Figure 7. Rainfall and daily maximum temperature during summer of 2020.

In the first summer of the guayule crop, the rainfall was unusually low, and temperatures were unusually high (see graphs above). This provided an opportunity to test drought tolerance of guayule crop in the deficit irrigation treatment.

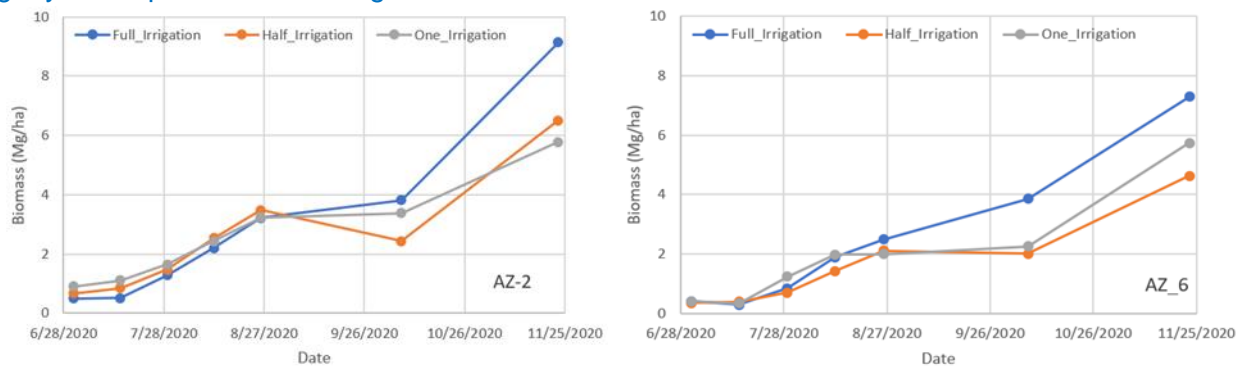


Figure 8. Biomass growth in three of six treatments.

During summer, three of the six treatments (1. Full irrigation, 3. Half Irrigation, 6. One irrigation per year) were sampled for biomass. After the last irrigation for establishment was applied to all treatment on June 18, 2020, the three treatments did not show significant differences until August 26, 2020 sampling. This indicates that although visual differences among treatments were observed, the differences in biomass production were small until late August. After that, biomass growth for both AZ-2 and AZ-6 stopped for the half irrigation and one irrigation per year treatments. The growth resumed after weather cooled down relatively, and an irrigation was applied on September 15, 2020 for the one irrigation per year treatment.

Although the half irrigation and one irrigation per year treatment had lower biomass yield by the end of November, plants in those treatments survived the hottest and driest summer in Arizona history. This showed extraordinary ability of guayule to tolerate drought conditions.

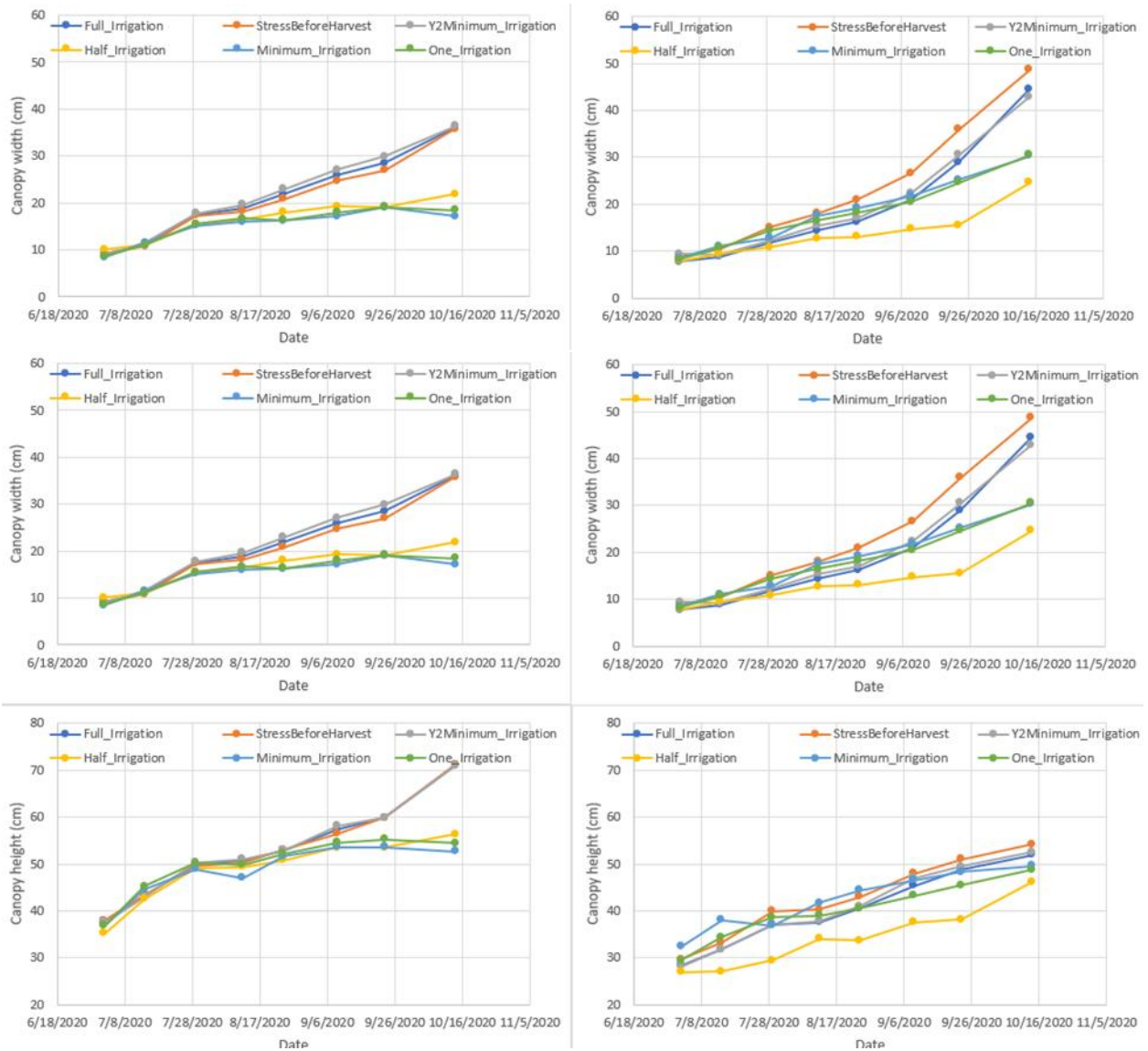


Figure 9. NDVI, canopy width, and canopy height of guayule during the summer of 2020.

After irrigation treatments began, a phenotyping platform was also used to record NDVI (normalized difference vegetation index), canopy width, and canopy height in the field. By design, treatments Full Irrigation, Stress Before Harvest, and Minimum Year2 were same in the first year, and treatments Minimum Irrigation, and One Irrigation Per Year were also same in the first year. NDVI, canopy width, and canopy height were consistent with visual observations and showed differences among treatments earlier than biomass. Although the Half Irrigation treatment received more water than the Minimum Irrigation and One Irrigation treatments, both biomass and phenotyping measurements were similar among these treatments.

Guar Response for Field Performance:

Nothing to report.

Guar Response to Salinity Tolerance:

Nothing new to report.

Guar Response to Moisture Stress:

The project was completed and a report submitted to the project director previously.

A manuscript draft was prepared, reviewed and edited titled: "Growth and Performance of Guar *Cyamopsis tetragonoloba* (L.) Taub under various irrigation regimes and biogenic silica addition in Southwest New Mexico". An abstract was based on results from this study published at the 2020 ASA-CSSA-SSSA International Virtual Meeting.

Guar Response to Planting Densities:

The seed density trial was harvested at Lyendecker Plant Science Center, Las Cruces, New Mexico. Square meter harvest samples were collected for final seed yields. Threshing of the square meter harvest samples will be completed in coming weeks with the thresher. Single plants were also collected and will be manually threshed for recording the observations on seed yield attributing characteristics.

Guayule Herbicide Tolerance Study, Fall 2020:

These field experiments were initiated in September 2020 at Bridgestone-Eloy (mid-September plantings) and at MAC (9/28/2020 planting); see table below for information on the fall experiments. Enough plants have survived establishment at MAC and Bridgestone (Eloy) to conduct these experiments; they are currently underway at MAC in field 5E, borders 21 and 22 and at Elly in fields B2W and B6.

The post-directed experiments will be conducted using the same plots/plants that are currently being used for the herbicide application sequence for chemical weed control studies from seeding to 6-months.



Photo 5. Guar plants at maturity. Las Cruces, New Mexico.



Photo 6. Taking guar plant measurements in the field, Las Cruces, New Mexico.

Table 6. Details from Fall 2020 herbicide experiments in Eloy, Arizona.

Spray Date	Chemicals Applied	Location/ Field	Method of Incorporation	ARM File Name / Data Tables?	Data Collected to Date
9-21-2020 (PPI Flat) 9-25-2020 (PPI bed-top)	Prowl H2O, Sonalan, Dual, Prefar, Spartan, Warrant	MAC / F5E / B19/20	PPI-flat, field cultivator, lister, bed-top, incorporator, irrigation	2020 FALL Herbicide Systems MAC F5E 19/20	9/21/2020 – applied Prowl and Sonalan in some plots – PPI flat 9/25/2020 – applied Dual, Spartan, Warrant, and Prefar PPI bed-top 9/28/2020 – Planted 9/29/2020 – Irrigated every other furrows
10-22-2020	Prowl H2O Aim MSO Activator 90	Bridgestone B6	Irrigation	2020 Fall Eloy Aim Sequential NIS MSO	10/21/2020 – Guayule 3 m stand counts 10/22/2020 – Leaf Counts 11/2/2020 – Guayule 3 m stand counts 11/11/2020 – Guayule 3 m stand counts 11/11/2020 – Nadir photographs 12/2/2020 – Nadir photographs 12/9/2020 – Leaf Counts 12/9/2020 – Sequential Aim Treatment 12/22/2020 – Nadir photographs 12/22/2020 – Guayule 3 m stand counts
11-6-2020	Prowl H2O Aim MSO Activator 90	MAC / F5E / B21/22	PPI-flat, field cultivator, lister, bed-top, incorporator, irrigation	2020 Fall Maricopa Aim Sequential NIS MSO F5E B21_22	11/5/2020 – Guayule 3 m stand counts 11/6/2020 – Leaf Counts 12/2/2020 – Nadir photographs 12/12/2020 – Necrosis rating 12/21/2020 – Nadir photographs 12/21/2020 – Guayule 3 m stand counts dead/alive 12/21/2020 – Leaf Counts 12/21/2020 – Sequential Aim Treatment
11-10-2020	Prowl H2O Aim MSO Activator 90	Bridgestone B2W	Irrigation	Fall Eloy Herbicide Systems Field B2	11/10/2020 – Guayule 3 m stand counts 11/10/2020 – Leaf Counts 12/9/2020 – Leaf Counts 12/9/2020 – Sequential Aim Treatment 12/22/2020 – Guayule 3 m stand counts 12/22/2020 – Nadir photographs

Because of an almost complete loss of guayule seedlings at MAC in field 5E, borders 19 and 20, this experiment was abandoned at MAC. It appears we may be able to find an alternative location at Bridgestone (Eloy) in field B6 and will attempt to start this experiment in Q1 of 2021.

Guayule Herbicide Tolerance Study, Spring 2021:

We will be conducting these studies in spring 2021. Data and summaries will be prepared and submitted to herbicide manufacturers in order to develop submissions for 24c-SLN registrations starting in 2020 Q4 and continuing until completed.

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

Nothing new to report.

Development and Testing of AquaCrop Model:

Wanyu Huang has been brought onto the research as a new graduate student focusing on the AquaCrop Model. Dr. Peter Waller's team is assisting with the analysis and working with the model.

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

Plants were harvested on 14 October 2020.

Range of N and P Utilization:

Nothing new to report.

Direct-seeded vs. Transplant-established Guayule:

Nothing new to report.

Monitor TDR, Infrared Cameras, and Flowmeter System:

TDR soil moisture, IR camera sensor systems are installed in the irrigation stress experiment at Eloy. The sensors have had some problems but in general are working. Danielle constructed a Bowen ratio station (evapotranspiration), which is ready for installation in Eloy. Remote sensing readings and analysis are ongoing in all guayule irrigation experiments.

WINDS Model Integration with Existing Tools:

There were some difficulties with calibration of the WINDS model in the guar experiment so we decided to check the model against an old cotton dataset with a complete soils and irrigation data. The evaluation went really well, and we are writing a paper based on the analysis. We will move on now to the guar experiment in which the WINDS model will be used to evaluate and check the data prior to running the AquaCrop model on the guar experiment.

The WINDS model can check for data integrity based on water balances and observed responses in the neutron measurements. Matt calibrated the WINDS model for the surface irrigation guayule experiment in the sandy loam soil in Maricopa. Pete needs to revise the Python and MySQL version of the WINDS model in order to run on Amazon Web Services as an irrigation management tool. Pete, Kim, and two graduate students are working on calibration of the AquaCrop model for guayule and guar experiments.

Irrigation Experiments – Guayule and Guar:

We applied the last irrigation for all guayule fields by mid-November 2020. Now, they will not be irrigated until Feb or Mar 2021 due to dormancy. However, data collection continued every other week for the remote sensing and soil moisture data and every month for manual plant measurements. Image processing and field data analysis also continued during the past three

months and manuscripts are being prepared for presentation at the 2021 ASABE annual meeting.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Maier/ Neilson	Physical analysis of Yr1 soil samples (n=108)	Soil texture characterization complete	31 Dec 20
2 Maier/ Neilson	DNA extraction of soil samples for microbiome analysis (Yr1 and Yr2)	MAC Yr1 complete MAC & Eloy Yr2 complete	28 Feb 21 28 Feb 21
3 Maier/ Neilson	Amplicon sequencing: bacteria, archaea, and fungi	MAC Yr1 and Yr2 complete Eloy Yr2 complete MAC and Eloy Yr3 samples complete	30 Apr 20 30 Apr 21 31 Oct 21
4 Maier/ Neilson	Winter dormancy rubber production studies	Manuscript submitted for review and publication	31 Aug 21
5 Maier/ Neilson	Temporal microbiome network analysis of community interactions	DNA extraction for 240 samples Bioinformatics of soil samples collected monthly	30 Jun 21 1 Mar 21
6 Maier/ Neilson	Annual soil quality analysis of guayule irrigation field (MAC and Eloy)	Assess relative abundance of putative guayule pathogens Assess soil microbe diversity Manuscript preparation for guayule pathogen analysis	31 Dec 20 31 Dec 20 1 Jun 21
7 Maier/ Neilson	Harvest analysis of irrigation field trial	DNA extraction of guayule field soil samples (MAC and Eloy) Amplicon sequencing of soil samples collected (MAC and Eloy) Statistical analysis of associations between microbial community and plant metrics	31 Dec 20 1 Feb 21 1 Aug 21

Chemical and Physical Analysis:

Soil texture analysis of Year 1 soil samples for the MAC and Eloy fields is now complete. Some analyses were done on Year 2 soils when replication was needed. In summary, all MAC soils were classified as Sandy Loam. The clay content ranged from 10.5 to 17.3%. Eloy soils were more variable and were classified as Loam, Silty Clay Loam, Clay Loam, and Clay. The clay

content for Eloy ranged from 24.4 to 42.7%, indicating that all Eloy soils had a higher clay content than any of the MAC soils. It is interesting to note that not all replicates of each irrigation treatment had the same soil texture in the Eloy field.

Table 7. Soil texture analysis: Guayule Irrigation Field Trial (MAC and Eloy, Arizona).

Eloy Soil Texture Analysis						MAC Soil Texture Analysis					
Sample ID	Plot	%Sand	%Silt	%Clay	Soil Texture Class	Sample ID	Plot	%Sand	%Silt	%Clay	Soil Texture Class
E1105011	2	24.5	39.6	35.8	Clay Loam	M1105011	4	67.1	22.3	10.5	Sandy Loam
E2105012	2	14.5	48.3	37.2	Silty Clay Loam	M1105012	4	66.7	18.5	14.8	Sandy Loam
E1105013	2	19.5	44.7	35.8	Silty Clay Loam	M1105013	4	67.1	20.6	12.3	Sandy Loam
E2105021	11	19.6	48.3	32.1	Silty Clay Loam	M1105021	8	69.7	18.8	11.5	Sandy Loam
E1105022	11	44.3	31.2	24.4	Loam	M1105022	8	69.7	16.3	14.0	Sandy Loam
E2105023	11	19.5	44.7	35.8	Silty Clay Loam	M1105023	8	71.9	14.1	14.0	Sandy Loam
E1105031	13	14.3	51.7	34.0	Silty Clay Loam	M1105031	14	67.1	18.8	14.0	Sandy Loam
E1105032	13	29.3	38.1	32.6	Clay Loam	M1105032	14	69.7	16.3	14.0	Sandy Loam
E1105033	13	24.4	44.6	31.0	Clay Loam	M1105033	14	67.1	18.8	14.0	Sandy Loam
E2107511	5	19.5	39.6	40.9	Clay	M1107511	6	67.0	19.0	14.0	Sandy Loam
E1107512	5	9.4	53.4	37.2	Silty Clay loam	M1107512	6	64.4	19.1	16.5	Sandy Loam
E1107513	5	24.2	39.8	36.1	Clay Loam	M1107513	6	67.0	16.5	16.5	Sandy Loam
E1107521	12	34.3	31.1	34.6	Clay Loam	M1107521	12	67.0	16.5	16.5	Sandy Loam
E1107522	12	24.5	43.2	32.2	Clay Loam	M1107522	12	67.0	17.3	15.7	Sandy Loam
E1107523	12	19.5	43.1	37.3	Silty Clay loam	M1107523	12	67.0	16.5	16.5	Sandy Loam
E1107531	17	10.1	51.2	38.7	Silty Clay loam	M1107531	16	64.4	19.1	16.5	Sandy Loam
E1107532	17	34.3	31.1	34.6	Clay Loam	M1107532	16	67.0	16.5	16.5	Sandy Loam
E1107533	17	19.5	43.2	37.3	Silty Clay loam	M1107533	16	67.0	16.5	16.5	Sandy Loam
E1110011	6	29.4	36.1	34.5	Clay Loam	M1110011	3	67.0	16.5	16.5	Sandy Loam
E1110012	6	14.4	44.7	40.9	Silty Clay	M1110012	3	66.8	16.6	16.5	Sandy Loam
E1110013	6	10.2	61	28.8	Silty Clay Loam	M1110013	3	69.4	14.1	16.5	Sandy Loam
E2110021	9	10.1	49.1	40.8	Silty Clay	M1110021	11	66.8	16.7	16.5	Sandy Loam
E1110022	9	24.4	39.6	36	Clay Loam	M1110022	11	66.8	16.6	16.5	Sandy Loam
E2110023	9	24.2	39.7	36.1	Clay Loam	M1110023	11	66.8	14.9	18.3	Sandy Loam
E1110031	14	24.3	46.7	29	Clay Loam	M1110031	15	66.8	16.6	16.5	Sandy Loam
E1110032	14	24.4	44.7	30.9	Clay Loam	M1110032	15	66.8	16.6	16.5	Sandy Loam
E1110033	14	24.4	37.8	37.8	Clay Loam	M1110033	15	69.4	14.1	16.5	Sandy Loam

E2112511	1	19.1	43.2	37.7	Silty Clay Loam	M1112511	5	67.0	19.0	14.0	Sandy Loam
E1112512	1	14.2	48.2	37.5	Silty Clay Loam	M1112512	5	64.4	18.4	17.3	Sandy Loam
E1112513	1	34.5	32.9	32.6	Clay Loam	M1112513	5	69.6	13.9	16.5	Sandy Loam
E2112521	8	19.2	39.6	41.1	Clay	M1112521	9	67.0	17.3	15.7	Sandy Loam
E1112522	8	24.6	44.7	30.7	Clay Loam	M1112522	9	67.0	16.5	16.5	Sandy Loam
E1112523	8	24.5	44.7	30.8	Clay Loam	M1112523	9	67.0	16.5	16.5	Sandy Loam
E1112531	15	24.6	39.6	35.8	Clay Loam	M1112531	13	64.4	19.1	16.5	Sandy Loam
E1112532	15	24.5	41.1	34.4	Clay Loam	M1112532	13	67.0	16.5	16.5	Sandy Loam
E1112533	15	19.5	46.2	34.3	Silty Clay Loam	M1112533	13	67.0	16.5	16.5	Sandy Loam
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E1115011	3	19.4	43.1	37.5	Silty Clay Loam	M1115011	1	67.0	16.5	16.5	Sandy Loam
E1115012	3	19.3	43.1	37.6	Silty Clay Loam	M1115012	1	64.4	18.3	17.2	Sandy Loam
E1115013	3	19.4	43	37.5	Silty Clay Loam	M1115013	1	69.6	13.9	16.5	Sandy Loam
E1115021	10	19.5	48.1	32.4	Silty Clay Loam	M1115021	10	67.0	16.5	16.5	Sandy Loam
E1115022	10	24.7	43	32.3	Clay Loam	M1115022	10	67.0	16.5	16.5	Sandy Loam
E1115023	10	24.6	43	32.4	Clay Loam	M1115023	10	67.0	16.5	16.5	Sandy Loam
E1115031	18	24.5	43.1	32.4	Clay Loam	M1115031	18	67.0	16.5	16.5	Sandy Loam
E1115032	18	24.5	43.1	32.4	Clay Loam	M1115032	18	67.0	16.5	16.5	Sandy Loam
E1115033	18	14.5	48.1	37.4	Silty Clay Loam	M1115033	18	69.6	13.9	16.5	Sandy Loam
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E1210011	4	19.2	39.6	41.2	Clay	M1210011	2	66.8	16.7	16.5	Sandy Loam
E1210012	4	19.3	39.6	41.1	Clay	M1210012	2	64.2	18.5	17.3	Sandy Loam
E1210013	4	14.1	50.2	35.7	Silty Clay Loam	M1210013	2	64.6	18.1	17.3	Sandy Loam
E1210021	7	14.2	48.2	37.5	Silty Clay Loam	M1210021	7	66.8	16.6	16.5	Sandy Loam
E1210022	7	14.2	43.1	42.7	Silty Clay	M1210022	7	66.8	18.4	14.8	Sandy Loam
E1210023	7	19.2	43.2	37.7	Silty Clay Loam	M1210023	7	64.2	18.5	17.3	Sandy Loam
E1210031	16	19.2	43.1	37.6	Silty Clay Loam	M1210031	17	69.4	14.1	16.5	Sandy Loam
E1210032	16	19.2	44.8	36	Silty Clay Loam	M1210032	17	66.8	16.6	16.5	Sandy Loam
E1210033	16	19.3	44.7	36	Silty Clay Loam	M1210033	17	66.8	16.6	16.5	Sandy Loam

DNA Extraction for Microbiome Analysis:

Progress has been made on the DNA extractions, but the work is still in progress. All 2018 MAC and Eloy samples have been completed, and the 2019 Eloy samples are complete. 25:54 2019 MAC samples are still in progress.

Amplicon Sequencing: Bacteria, Archaea, Fungi:

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

Winter Dormancy Rubber Production Study:

Data discussions with McMahan research group and manuscript figure and table preparation were completed in Q3.

Temporal soil microbiome associated with quayule growth cycle:

DNA extractions from the 240 soil samples collected for this project are now complete.

Annual Soil Quality Analysis of Guayule Irrigation Field (MAC and Eloy):

COVID restrictions have limited K. Brown's ability to work in the lab to complete Year 3 Tasks. While working remotely, he completed a literature review on potential effects of irrigation management on putative fungal pathogen abundance patterns.

Under guidance from UA Plant Pathologist, Dr Alex Hu, Brown has identified six putative guayule pathogens. These include *Pythium* spp. *Rhizoctonia solani*, *Phytophthora drechsleri*, *Fusarium* spp. *Sclerotinia* spp., and *Macrophomina* spp. A literature review revealed that *Pythium* spp. and *Phytophthora drechsleri* are classified as Oomycetes which are motile and proliferate under saturated conditions. The life cycle of these pathogens requires the wet and dry cycles typical of flood irrigation. Studies have shown greater abundance of these fungi and greater occurrences of root-rot disease under flood irrigation as compared to drip irrigation. In contrast, the other four fungal phylotypes are non-motile True Fungi which may proliferate more under drip irrigation when the moisture is delivered within the root-zone and is accessible to non-motile fungi. Brown will use the information from this literature review to guide hypotheses developed. The effect of irrigation treatment on the relative abundance of these putative pathogens will be quantified. The results of his literature review were presented in the SBAR weekly meeting on November 18, 2020. A second literature review is in progress assessing current knowledge on the impact of bacterial, archaeal, and fungal diversity on the relative abundance of plant pathogens in agricultural soils. He hypothesizes that the overall diversity of total fungi will impact fungal pathogen abundance more than the diversity of bacteria or archaea.

Temporal Soil Microbiome Network Analysis Associated with Guayule Growth Cycles:

240 samples were collected from Eloy fields during 2019 and 2020 and all DNA extraction of these samples is complete. Amplicon sequencing for bacteria/archaea and fungi was performed on these samples in December by the UA Genomics Core, but the sequence data generated was not acceptable. The extracts have been resubmitted for sequencing and the work is being done at this time.

Y. Chen defined a revised objective for this project for the annual meeting presentation. His research objective is to define the core microbiome associated with the guayule plant across multiple growth stages and environmental conditions. Characterization of this core microbiome will facilitate comparisons between guayule growth performance, environmental factors and deviations from this core microbiome. This objective was informed by Chen's work during Q3 on a publication characterizing *Life-history strategies of soil microbial communities in an arid ecosystem*. This paper was published in the prestigious ISME J (International Society of Microbial Ecology Journal) in October 2020. In this manuscript, Chen compared the microbial traits of communities that colonize vegetated and barren soils in natural arid ecosystems.

Harvest Analysis of Irrigation Field Trial:

DNA extraction of the Year 3 field trial samples collected in March 2020 (Task 3a) has not begun due to COVID delays. This project will be initiated when the Task 1 pathogen analysis project is complete. Chemical analysis of these March 2020 field soils has not been done. We anticipate that the COVID restrictions will allow us to complete this soil analysis this quarter.

CHARACTERIZATIONS & CO-PRODUCTS

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

Issues/Risks:

Brewer: No additional work was done on the third of three biomass conversion review manuscripts, on low-cost waste/residue feedstocks for biofuels in Q4 as Bayat's time was taken up by her work on the NSF education grant providing her research assistantship. (Bayat did not receive any SBAR support during the fall semester.) Work on that manuscript will be picked up again in 2021 Q2 after Bayat completes her PhD comprehensive exam.

Gunatilaka: The postdoc, Dr. M. Chandrashekhar, working on this project left for another position. His departure caused some delays in the preparation of the manuscript for *Bioorganic and Medicinal Chemistry*.

Holguin: Dr. Jarvis has resigned from NMSU. She was responsible for the high-resolution analysis of guayule products. We anticipate that we will continue our working collaboration through an affiliated faculty status. However, this has significantly slowed our progress on the interpretation of the FTICR data.

COVID-19 guidelines allowing only essential activities to continue has delayed us. We were not able to complete all our projects by the term of Q4, we will be diligently working to complete work by Q1 of 2021 (>6-month delay).

We previously reported that a gas chromatography instrument, our primary instrument for metabolomics work, is still nonfunctional. Parts have been received and installed, but the instrument did not pass verification. We have reached out to another lab on campus with a GC/MS to help complete our work.

Repairs are complete on our nitrogen generator that is used to support all the LC/MS units, the CHNOS analyzer is giving an error and is being trouble-shooted with Perkin Elmer reps. The -80C freezer was not repairable and we are using alternative freezers for samples.

Ms. Claudia Galvan is overseeing chemical analysis as a new laboratory manager for the Holguin lab. She is diligently working to bring the projects back on schedule. However, due to COVID restrictions for on campus activity, this has increased our backlog to attending to sample analysis.

Molnár: Due to work permit processing, Dr. M. Cascaes-Inacio joined the project and started experimental work on 21 October 2020, delaying the start of the biotransformation, compound isolation, and characterization work.

Ogden: We are still being affected by the Coronavirus disease (COVID-19). The situation was better but turned worse at the end of the year. We have a better adjustment to work efficiently under the pandemic, but still got affected by the situation.

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	Identify metabolic pools and gene targets for cold adaptation, rubber production, and survivability Identify minor resin components for resin byproducts	31 Dec 20 31 Aug 21
2 Holg	Biochemical composition analysis of guar and respective products	Develop methods to characterize polysaccharide composition of select varieties of guar	31 May 21
3 Holg	Commissioning and testing of supercritical fluid extraction equipment and analyses	Chemical analysis of SFE extracts and contribute to manuscript development	31 Aug 21

Guayule Biochemical Composition Analysis:

Dehghanizadeh et al., (2020) identified many metabolites extracted from guayule resin based on both GS-MS and FT-ICR MS analysis. Cheng et al., (2020) complemented the first publication with new data and thorough interpretation of ICR data. GS-MS technique has several disadvantages such as it detects only volatile compounds and compound with m/z around 1300 are missing. Simple tandem MS analysis is warranted in order to detect and identify non-volatile metabolites.

Following Rozalén et al., (2021) we identified Guayulin B and D (Table 8). Fragmentation patterns were more or less consistent with published ones with minor differences. Our analysis is showing that MSMS fragments are different between Guayulin B and D: for example, Guayulin D did not show following fragment - 93.08. Hypothetical fragmentation of the Guayulin D molecule together with fragmentation patterns is shown in Figure 10. Additionally, Argentinine A, B, C, D (Figure 11) was found in the resin mixture. There were at least 10 MSMS spectra similar to Guayulin with following



Photo 7. A guayule plant from the cold response studies conducted in New Mexico.

m/z: 356, 359, 372, 374, 382, 400 (major fragment 109, 135). Also, there were at least 20 MSMSs similar to Argentatine, with following m/z: 386, 388, 404, 406, 412, 414, 438, 440, 454, 474, 488, 490, 504, 506, 536, 572, 606 (major fragment 219). Whether or not all these masses resemble separate compounds is the future questions to answer. Some of the spectra could be adducts or just differently fragmented molecules. Next step would be to isolate particular masses in order to decide whether these fragments are real compounds.

Table 8. Major fragments of a Guayulin spectra, numbers inside the cells are m/z.

Guayulin B	93.08	105.09	107.09	109.11	119.1	135.09	147.14	161.15	173.16	185.18	226.09
Guayulin D	X	105.08	107.09	109.09	X	135.08	147.08	161.15	173.17	185.01	226.09

Guayulin D [M+H]⁺ m/z 371

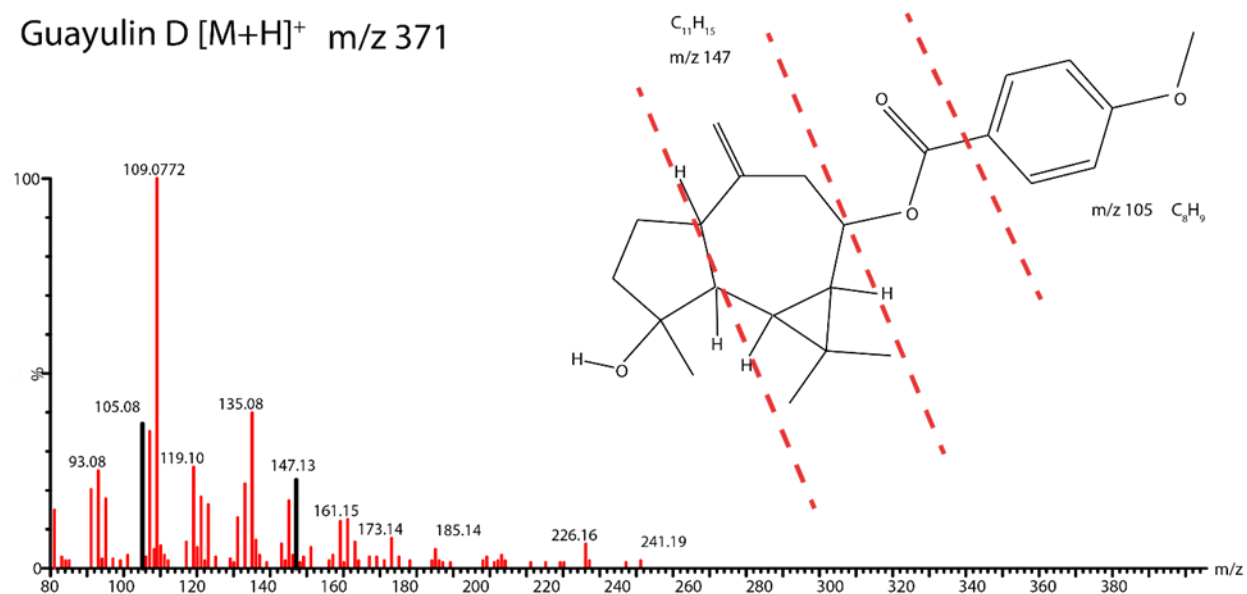


Figure 10. Proposed fragmentation of the Guayulin D molecule based on Rozalén et al. (2021).

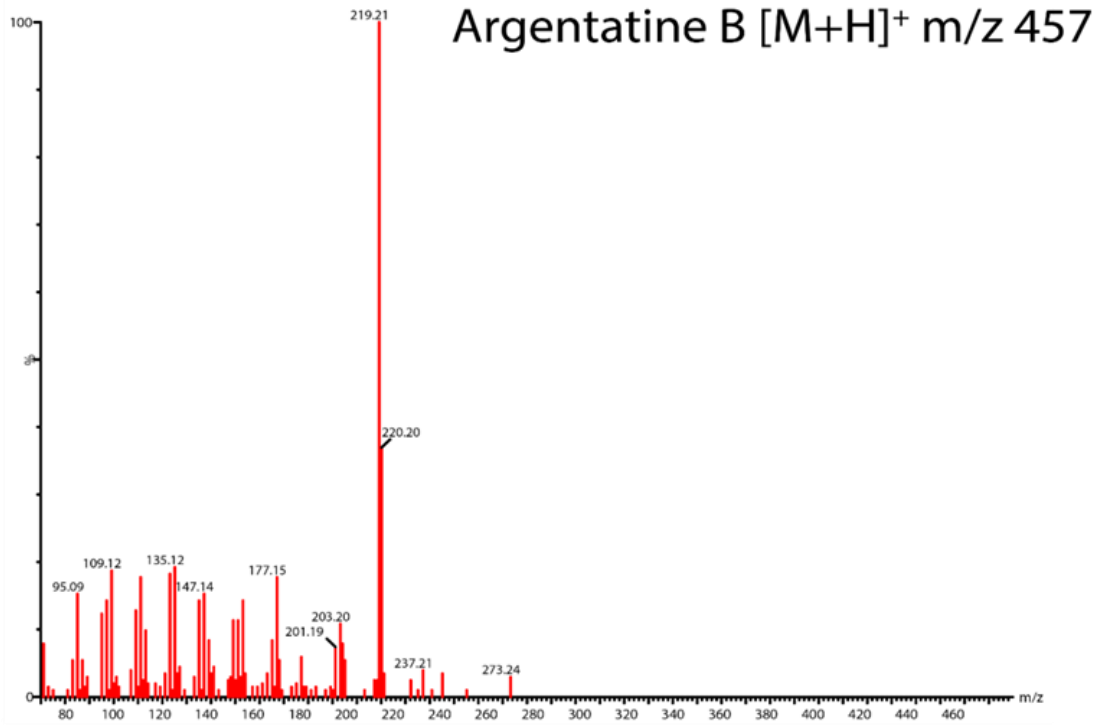
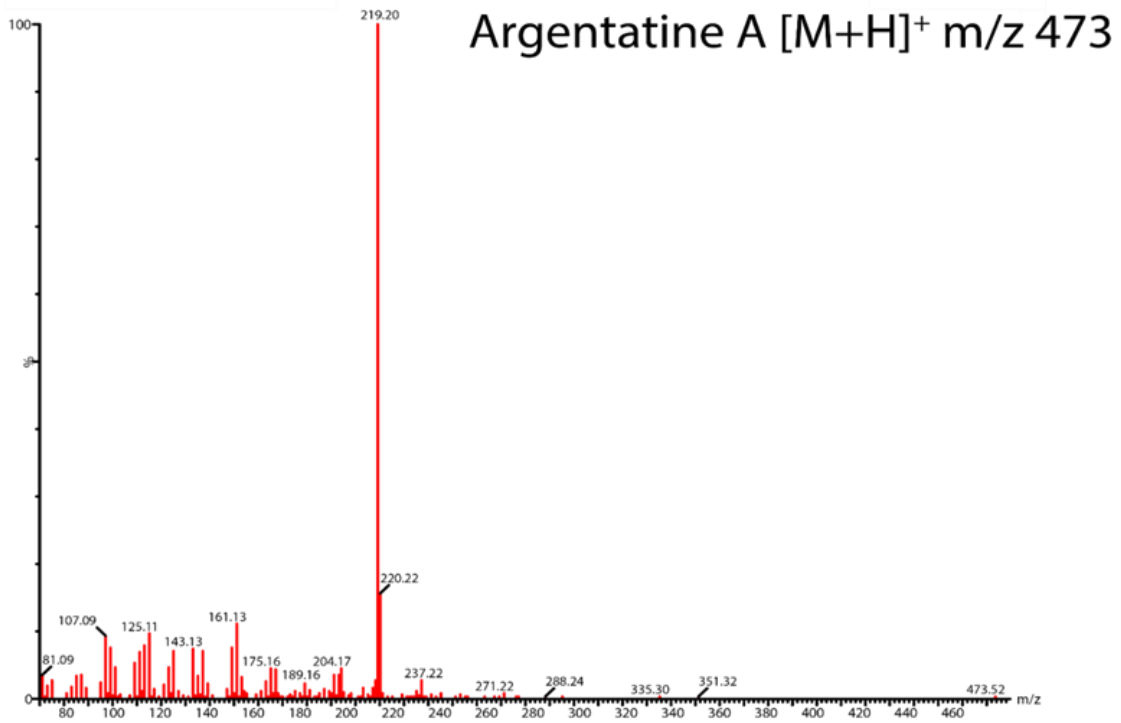


Figure 11. Fragmentation patterns of Argentatines.

References

- Cheng, F., Dehghanizadeh, M., Audu, M.A., Jarvis, J.M., Holguin, F.O., Brewer, C.E., 2020. Characterization and evaluation of guayule processing residues as potential feedstock for biofuel and chemical production. *Ind. Crops Prod.* 150, 112311. <https://doi.org/10.1016/j.indcrop.2020.112311>
- Dehghanizadeh, M., Cheng, F., Jarvis, J.M., Holguin, F.O., Brewer, C.E., 2020. Characterization of resin extracted from guayule (*Parthenium argentatum*): A dataset including GC–MS and FT-ICR MS. *Data Br.* 31, 105989. <https://doi.org/10.1016/j.dib.2020.105989>
- Rozalén, J., García, M.M., Zalacain, A., López-Córcoles, H., Hurtado de Mendoza, J., Cornish, K., Carmona, M., 2021. Future trends for the analysis of guayulins in guayule (*Parthenium argentatum* A. Gray) resins. *Ind. Crops Prod.* 159. <https://doi.org/10.1016/j.indcrop.2020.113027>

We have also attended bimonthly meetings with Bridgestone to discuss the guayule manuscript and harvesting of new samples, monthly NMSU SBAR and SBAR Characterization and Co-Products meetings.

We have submitted the guayule write up “Metabolic Biomarkers in Cold and Freezing-resistant Guayule” for the Characterization and Co-Products section of the SBAR website and the December 2020 SBAR Extension Newsletter. Completed DNA sequencing of the **16S rRNA** gene amplified by polymerase chain reaction (PCR) from genomic DNA of bacteria recovered from the Los Lunas guar nodules. Completed the multiple alignments and identification of the bacterial r16S gene.

Publications – Upon forwarding a previous draft of the publication “Natural Products in the Desert Southwest: Guayule (*Parthenium argentatum*) and Guar (*Cyamopsis tetragonolobus*),” one co-author has suggested major revisions to the economics sections of the paper, which Ms. K. Laje has completed. The manuscript has been sent back to co-authors for approval, and we feel strongly that this is the final round of revisions before journal submission to the “Plant Management Network,” scheduled for the end of January, 2021. Unfortunately, delays to the submission of this publication have occurred due to COVID-19/scheduling difficulties, as well as some minor communication issues from one co-author. Both problems have been alleviated through the team-work of project participants and co-authors.

Guar Biochemical Composition Analysis:

Submitted write up on guar results for the Characterization and Co-Products section of the December 2020 SBAR Extension Newsletter.

Commissioning and Testing Supercritical Fluid Extraction Equipment and Analyses:

Nothing new to report.

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:

This task is complete; nothing new to report.

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	Perform liquid-liquid, accelerated, and filtration separations; characterize fractions from guayule resin	Manuscript of guayule resin separation/characterization	31 Aug 21
2 Brewer	Conduct tests of guayule resin-derived materials for insect repellency applications	Manuscript on potential insect repellency	31 Aug 21
3 Brewer	Characterize biomass and fraction samples	Characterizations data provided to SBAR team to support sustainability models	31 Aug 21
4 Gunat	Evaluate major metabolites of guayule	Evaluate transformation products of argentatins A, B, C for potential anticancer/antimicrobial activities	30 Nov 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
		Submit manuscript to <i>J. of Agricultural & Food Chemistry</i>	28 Feb 21
6 Gunat	Complete work on semi-synthesis, characterization of products, and biological evaluation of nine pyrimidine analogues of guayule resin	Draft manuscript complete; submitted to <i>Bioorganic and Medicinal Chemistry</i>	28 Feb 21
7 Molnár	Comprehensive literature/bioinformatic review to identify major classes of guayule secondary metabolites	Retrobiosynthetic analysis of major products of guayule resin/terpenes	31 Dec 20
		Bioinformatic identification in guayule genome/transcriptome databases	31 Jul 21
8 Molnár	Evaluation of microbial transformations in guayule resin or terpene solution	Develop methods for use of recombinant yeast strains, filamentous fungi, and chemical	31 Aug 21

		semisynthesis for conversion to value-added co-products	
9 Molnár	Characterize novel compounds originating from biotransformation or semisynthesis as potential value-added co-products	Isolation, structure elucidation, and evaluation of antimicrobial and anticancer bioactivities	31 Aug 21
10 Ogden	Characterization of pure resin and blended adhesives	IP disclosures 2 papers submitted for review	31 Oct 20 31 May 21
11 Ogden	Distillation of resin into multiple fractions	Distilled fractions analyzed MS Thesis complete; separation strategy hypothesized	31 Dec 20 31 May 21

Liquid-liquid, Accelerated, and Filtration Separations and Characterizations from Guayule Resin:

Rosalez defended his MS thesis on algae + guayule co-hydrothermal liquefaction and graduated in December. Bayat and the undergraduate students continued characterization of the bio-crude oils and chars towards preparation of the manuscript, which is planned for submission to a special issue of *Energies* in late spring/early summer.

The review article manuscript on biochemical conversion of high-protein, high-lignin feedstocks that was submitted to *Renewable & Sustainable Energy Reviews* is still listed as under review. (The journal informed us that they are extraordinarily delayed on their review processes due to COVID.) Dehghanizadeh, Brewer, and members of the Quinn group revised and resubmitted the guayule resin review article to *Industrial Crops & Products*.

Dehghanizadeh and Brewer provided updates for the Characterization and Co-Products SBAR webpage, and met with DeDecker and White from Bridgestone to discuss plans for guayule resin separations and applications.

Insect Repellency of Guayule Resin:

Dehghanizadeh and Soliz worked with the Romero group to continue the cockroach repellency tests for the resin fractions. They modified the bioassay to enable work with much smaller resin amounts for the 18 resin fractions obtained from the Gunatilaka group. Those results and resin fraction characterization data will be used to prepare a manuscript for publication in an entomology journal.

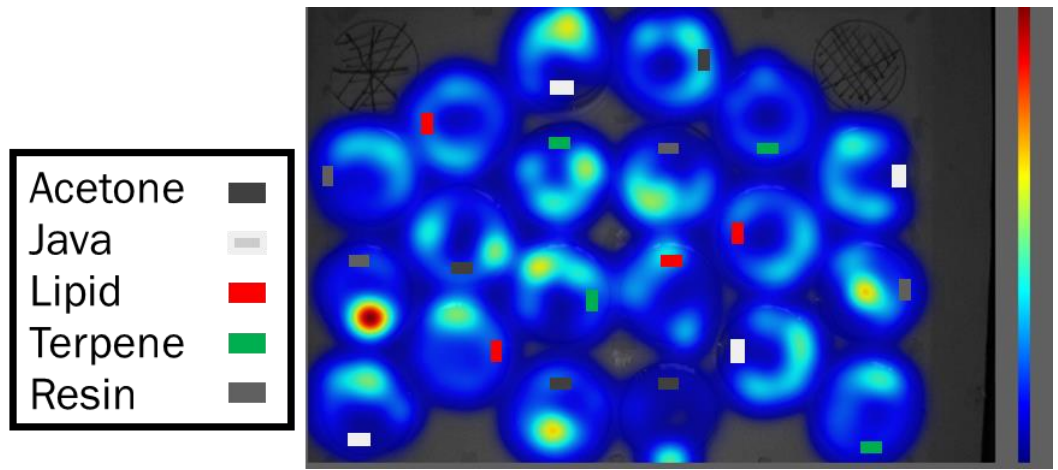


Figure 12. Cockroach activity during experiments; lighter blues indicate location preference.

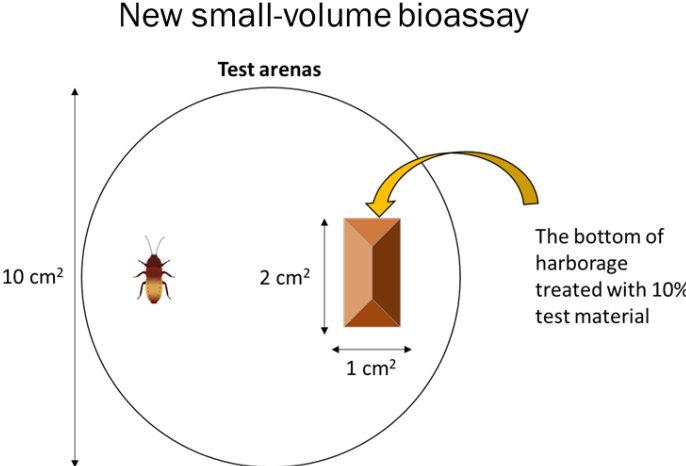


Figure 13. Diagram of insect repellency test environment.

Characterization of Biomass and Fraction Samples:

Dehghanizadeh and the undergraduate students developed the experimental safety plans for the supercritical fluid extraction system and completed the first HAZOP review. A final HAZOP review will be conducted in January once the blast shields/gas detectors/cryogen tanks are installed. Progress suggests that we will be able to meet the resin separation experimental and publication targets for Year 4.

The Waters (TharSFC) SFE-2000F2-1-C50 extraction system consists of a 2 L extraction vessel, two 500 mL fraction collecting vessels, an automatic back pressure regulator (ABPR, 600 Bar Max), two manual back pressure regulators (MBPR, 380 Bar Max), a heat exchanger, P-50 high pressure CO₂-solvent pump, a P-200A high pressure CO₂ pump, a temperature controller and a chiller.



Photo 8. Supercritical fluid extraction system in high-pressure equipment lab, awaiting installation of blast shields, workstation, and cryogen tanks.

Evaluate Major Metabolites of Guayule:

Fifteen synthetic analogues of argentatins A–C and the parent compounds were screened for their cell proliferation inhibitory activity against a panel of three human cancer cell lines [NCI-H460 (non-small cell lung), MCF-7 (breast adenocarcinoma), and normal human fibroblast (WI-38) cells]. The results showed that five of the fifteen analogues had enhanced cell proliferation inhibition activity compared to the parent compounds, argentatins A–C.

Table 9. Cell proliferation inhibitory activities of argentatins A-C and five of their most active semi-synthetic analogues.

Compound	Cancer cell line / IC ₅₀ (μM)		Normal cells / IC ₅₀ (μM)
	Non-small cell lung (NCI-H460)	Breast (MCF-7)	Fibroblast (WI-38)
Argentatin A	31.20±0.00	32.80±1.20	41.40±2.80
Argentatin B	17.50±0.90	23.10±0.40	21.00±2.90
Argentatin C	>35.00	>35.00	>35.00
2-Aminopyrimidine analogue of argentatin A	4.01±0.79	3.76±1.01	9.80±1.02
2-Pyrimidone analogue of argentatin A	4.38±0.66	4.03±0.39	10.47±0.58
2-Aminopyrimidine analogue of argentatin B	3.82±0.84	5.71±0.63	8.16±1.16
2-Pyrimidone analogue of argentatin B	3.95±0.28	3.59±0.14	5.88±0.47
2-Pyrimidone analogue of argentatin C	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

Isolate and Characterize Major Metabolites of Guayule Terpene Solution:

A manuscript was completed and forwarded to our collaborators from Bridgestone for their comments/input and to obtain approval from their board of directors for publication of this work. The required permission has now been obtained and the manuscript is currently undergoing

minor modifications to be submitted to *Journal of Agricultural and Food Chemistry* before 28 Feb. 2021.

Semi-synthesis, Characterization of Products, and Biological Evaluation of Guayule Resin:

The work on semi-synthesis and biological evaluation of all fifteen analogues from the three major coproducts of guayule resin, argentatins A–C, has been completed and the first draft of the manuscript describing this work has been completed. It will be submitted to *Bioorganic and Medicinal Chemistry* before 28 Feb. 2021.

Literature/Bioinformatics Searches:

Bioinformatic analysis of the draft genome sequence of guayule (provided by USDA-ARS) was conducted to find oxidosqualene cyclase (OSC) enzyme-encoding genes that represent the first committed step towards the biosynthesis of argentatins, major triterpenoid products from guayule resin. OSC gene fragments were then manually extended with non-scaffold and/or non-assembled reads from the genome sequencing if possible, and the resulting contigs were manually annotated. Three complete and two partial OSC genes were detected for beta-amyrin synthesis; one complete and three partial OSC genes were found for dammarene synthesis; and one complete OSC gene was detected for lupeol synthesis. Importantly, three complete OSC gene sequences were found for cycloartenol synthesis: this carbon skeleton is the most likely first cyclic precursor in argentatin biosynthesis. In collaboration with the McMahan group, these three cycloartenol synthases (CASs) were used to mine transcriptome databases. This analysis revealed that one of the predicted CAS is not represented in the transcriptome. Together with the presence of internal stop codons, this indicated that this gene (CAS205226) is likely a pseudogene, and may be disregarded from future analysis. The other two predicted CASs (CAS073979 and CAS484873) are 100% identical to expressed transcripts (validating the genome analysis), and show a roughly 3-fold reduction in expression under drought conditions. These two CASs are the prime candidates for the biosynthesis of the argentatin skeleton.

Genome mining for sesquiterpene synthases (STS) was conducted – the first committed step of guayulin biosynthesis is predicted to be catalyzed by an STS. Experimentally validated bicyclogermacrene synthases (BCGSs) from several plants were used as baits, and identified 36 guayule STS sequences (19 partial, including at least 2 likely pseudogenes) in the genome assembly. Validation and sorting of these genes/gene fragments using the transcriptome databases, and by phylogenetic analyses will be attempted next to narrow the list of BCGS candidates that may be responsible for guayulin biosynthesis.

Evaluate Microbial Transformations and Continue Chemical Transformations of Major Metabolites in Guayule Resin:

A fungus from the Natural Products Center strain collection, identified as a *Chaetomium* sp. by rDNA genotyping, was used to biotransform argentatin C in a resting cell assay and with actively growing cultures (“feeding”), and product formation was monitored at days 3, 5 and 10. The resting cell assay showed low level of biotransformation. The feeding assay revealed 3 new, more polar compounds (as shown by TLC), one of which (P1) disappeared by day 10. LCMS confirmed the presence of the three new compounds, and the almost complete disappearance of the starting material (argentatin C) by Day 5. New products P1 and P2 show an Mw that is 12 Da less than argentatin C (loss of a carbon, or loss of an oxygen plus a 4 electron reduction), while the Mw of product P3 (the main product after Day 5) is 16 Da higher than argentatin C

(likely hydroxylation). Pilot biotransformations of a mixture of argentatin A and iso-argentatin A, and separately, argentatin B were also conducted using the *Chaetomium* sp. The analysis of these experiments is ongoing.

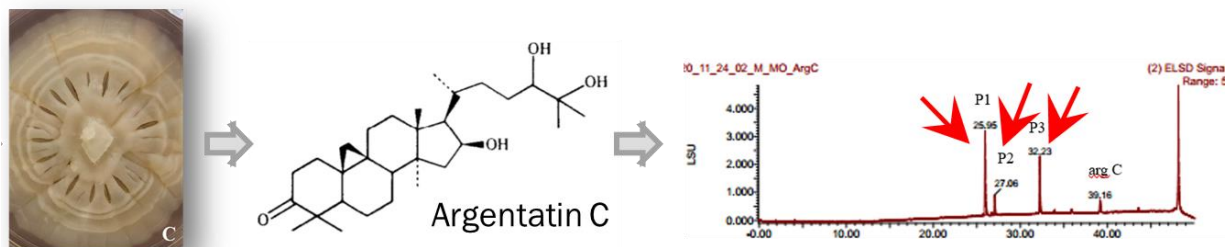


Figure 14. A *Chaetomium* sp. fungus from the NPC strain collection used to biotransform isolated guayule resin metabolites.

Characterize Novel Compounds from Biotransformations/Semisynthesis as Value-Added Products:

Scaling up biotransformations for compound isolation has started.

10 guayulin derivatives were investigated for antimicrobial activity against *E. coli*, *S. aureus*, *P. aeruginosa*, and *C. albicans* as the targets, but no significant activity was detected.

Characterization of Pure Resin and Blended Adhesives:

We continue to study guayule resin as a potential high-value-added product. We have a better adaption to do all experiments with cautions under COVID restriction policies. We have access to most of the needed facilities. In addition, we have been looking for facilities to analyze the resin/resin-adhesives samples and already found some at a local company in Tucson.

Sarocha is still focused on resin-protein characterization and tried to extend the study to identify the modified resin compositions and structure with collaborators, but there are some delays and obstacles due to the global pandemic situation and the retirement of our collaborator. She did an additional characterization of resin and resin-soy protein adhesives that is necessary for the manuscript underway.

Dr. Ogden successfully found a place for Sarocha to work on resin adhesive experiments at Advanced Ceramics Company as an alternative besides Kansas State University. Sarocha mainly worked at the company to build an environmental control chamber that is needed for resin/resin-adhesive research.



Photo 9. Resin extractions performed in the lab.



Photo 10. Environmental control chamber built for experiments in Tucson, Arizona.

In the next quarter, Sarocha will continue the experiments, write a manuscript and do further development with guayule resin adhesive and particleboard.

Distillation of Resin into Multiple Fractions:

A. Smith performed further vacuum distillation at pressures down to 0.06 PSI. Guayulins were distilled at low pressures (0.06 PSI) and high temperature (>220 C) but argentatins could not be. He found that taking liquid samples during distillation showed minimal breakdown of guayulins at 150 C, yielding a possible distillation column temperature. Distilling after a chemical separation of low molecular weight rubber was attempted, but the lack of expected terpenes in distillation will necessitate repeating the experiment. We will be working on vacuum distillation transesterification, and ASPEN modeling. We will begin to pay K. Burke (undergraduate student), but he is currently out on leave.

In the next quarter, work will continue on the distillation experiments varying pressure and study the effects of removing the low molecular weight rubber before the distillation process as well as writing a distillation model in ASPEN.

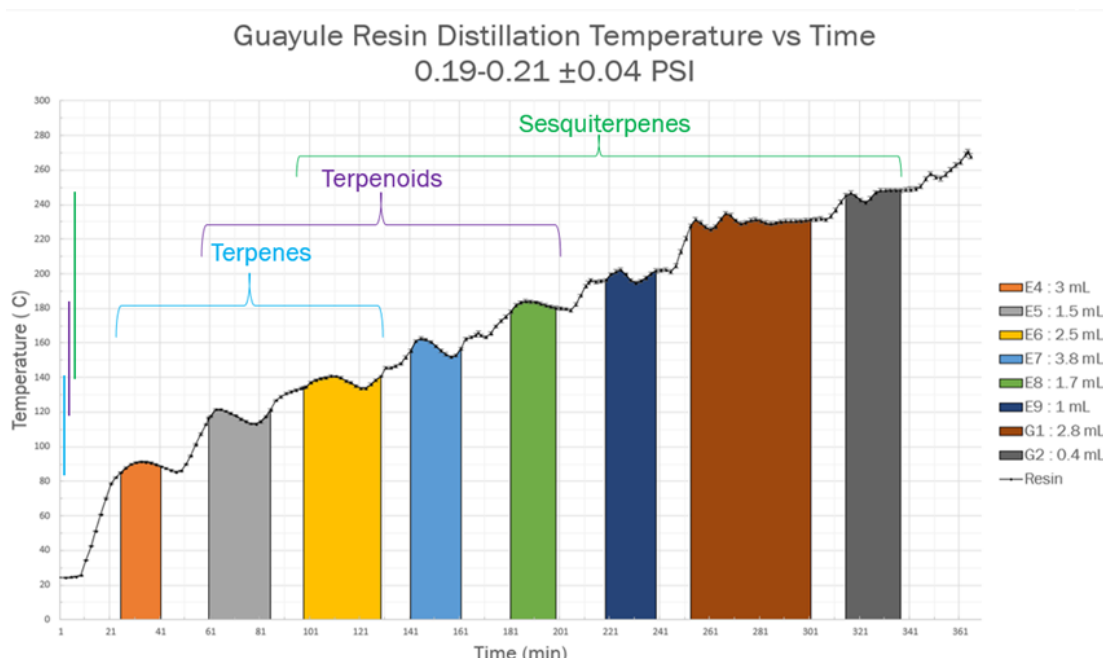


Figure 15. Vacuum distillation results obtained in the lab.

SYSTEM PERFORMANCE & SUSTAINABILITY

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

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

The focus this quarter has been:

- Continued development and integration of downstream bagasse to fuel process models
- Supporting manuscripts and research in the area of co-products (Brewer)
- Refinement of the integrated models
- Model integration across the sustainability team focused on validation and improved fidelity
- Developing water LCA scenarios
- Integrating downstream fuel modeling pathways in the guayule integrated model
- Development of moderation of sustainability team meetings on a bi-monthly basis in support of research goals
- Supporting CSM

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

Issues/Risks:

Fan: One issue is related to the input of parameters and verification of our models for guar supply chain. However, we have not received feedback from Guar Resources for a while. The sustainability team is discussing alternatives to address this issue.

Landis: One issue is working through a VBA and @Risk compatibility error. I am managing this by troubleshooting with CSU and it should be resolved in a couple of weeks. This error is slowing the probability distribution setting for the remaining inputs and the uncertainty and variability results production.

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	Conduct input/output analysis of system model results (IMPLAN)	31 Aug 21
		Validate preliminary analysis for farm production and profitability	31 Aug 21
		Develop market/transportation study to optimize industry location	31 Aug 21
2 Gutierr	Develop/test online producer systems model	Create online tool for evaluating guar/guayule alternative crops	31 Mar 21
3 Landis	Field data transfer	Field trial database updated with data quality codes for guar and guayule	31 Oct 20
4 Landis	Integrate guayule field data into LCA/TEA model	Updated LCA/TEA results and capability to choose likelihood for guayule	1 Dec 20
5 Landis	Support incorporation of guar data into LCA/TEA model	Collect data that enables LCA/TEA results for guar	15 Dec 20
6 Landis	Define guayule Monte Carlo parameters within model; run Monte Carlo analysis	Updated guayule field data	15 Jan 21
		Monte Carlo analysis report for guayule (integrated model)	
7 Landis	Guayule: Statistical analysis on field data; compare to baseline model	Statistics report and comparative graphs generated/complete	15 Feb 21
8 Landis	Guar: Support best-fit probability distributions	Field data updated; methods documented	28 Feb 21
9 Landis	Sensitivity analysis (integrated model)	Tornado plots and report on model parameters causing most impact	15 Mar 21
10 Landis	Support guar manuscript development	Data support provided to sustainability team	15 May 21
11 Landis	Guayule scenario analysis	LCA/TEA results and report comparing scenarios to baseline	30 Apr 21
12 Landis	Guayule manuscript development	Draft manuscript circulated within sustainability team for review	15 Mar 21
		Manuscript generated and submitted to peer review journal	15 May 21
13 Miller	Transition NM SBAR Sustainability work to new personnel	Attend meetings; identify and articulate specific contributions	31 Mar 21

14 Miller	Validate farm level scenarios within system model	List of assumptions compiled; parameters for acreage, production values, and relevant technology	30 Apr 21
15 Miller	Evaluate economic impacts in rural areas using whole farm budgets and input models	IMPLAN model analysis for crop adoption; report generated for Extension dissemination	31 Aug 21
16 Quinn	Techno-economic and Life Cycle Assessment results	Update/finalize economic and environmental impact results Manuscript on water use for guar submitted to peer review	1 Aug 21 1 Sep 21
17 Quinn	Data integration	Integrate experimental data into foundational processing model	1 Sep 21
18 Seav	Validated integrated model, including alternative crops	Updated integrated model to evaluate farm-level economics	31 Aug 21
19 Teeg	Facilitate working agreement between Tribal Farms and Bridgestone to establish experimental plots	At least one experimental plot established on Tribal lands	31 Aug 21
20 Teeg	Validated integrated model	Update and incorporate new information under various scenarios	31 Aug 21

Functional Integration of Economic Analysis into System Model:

The goal of identifying farm level inputs to be used in the integrated systems model is currently being reevaluated for guayule. The whole farm-level economic analysis for integration into the system model continues to evolve/improve as new production and economic data become available. Efforts to update input and cost parameters based on research results is a continuous process.

Future Plan – Efforts will continue to coordinate with TEA and LCA team members to enhance the integrated model and provide economic information to the team for publications and presentations.

Online Producer Systems Model:

Addressing producer’s questions on sustainability and production of guar and guayule in southern New Mexico is ongoing.

Future Plan – As we learn more about the producers who may want to grow guayule and guar in other geographical regions, additional crop budgets in the model will be created. Starting early this year (2021), additional regional analysis using IMPLAN, a regional I-O model will be conducted based on improved information from integrated model. In partnership with NM and AZ Farm Bureaus, we will virtually encourage participation of producers from two culturally distinct regions of AZ and NM (Northwestern NM and Northeastern AZ).

Field Data Transfer:

The field trial database has been updated with data quality codes for guayule and guar. V. Mealing has interviewed field trial PIs to collect qualitative indicators of data quality (likely, unlikely, optimistic), code and enter data into the integrated model. She has completed the

second round of meetings with the PIs of the field trial data in order to collect the new field data from the October 2020 most recent harvests. The data that was readily available has been added to the databases and integrated. These meetings were also used to collect sNnome equipment and management practices needed specifically for the Economics/TEA updates with field data.

Continued thanks to the support of the sustainability team and all field trial collaborators!

Integrate Current Guayule Field Data into LCA/TEA Model:

All six of the guayule field trials have been integrated into the integrated model as well as six of the guar field trials. Capability to choose different field trial scenarios has been implemented and results figures are populated for each scenario. Data probability (likely, unlikely, optimistic) has been collected via interviews with the field trial PIs and has been added to the field trial databases. The full accurate propagation of the new field trial data through the TEA and LCA are in progress as we adjust and add some new processes (for TEA & LCA) that were not in the original model version.

Table 10. Guayule field trial data summary.

Site/Location	Study Purpose	Lead PI & Researchers	Yields included?
MAC	Irrigation trial	Diaa, Dave D & Pete W	Yes
Eloy	Irrigation trial	Diaa, Dave D & Pete W	Yes
Eloy	Density trial	Sam	Yes
Tucson	Density trial	Dennis	Yes
MAC	Variety trial	Dennis	Yes
Eloy	Variety trial	Dave, Mark cruz	Yes
Eloy	Herbicide study	Bill M	No

Support Incorporation of Guar Data into LCA/TEA Model:

See above for more detail.

Define Guayule Monte Carlo Parameters Within Model and Analyze:

V. Mealing gave a presentation to the Sustainability team on the overview of the field trial data integration uncertainty and variability and use of @Risk. Best fit probability distributions have been set for yields and preliminary uncertainty and variability analysis results have been produced for the general category of all averaged data in the guayule model for the yield input. Similar results production is in progress for the many variation of data averaging available in the model (e.g. likely, unlikely, optimistic) for all the inputs available. This will be done once the accurate LCA propagation has been ensured and once the VBA and @Risk error is resolved.

Guayule: Statistical Analysis on Field Data Compared to Baseline:

Nothing new to report.

Guar: Support Best-Fit Probability Distribution:

Nothing new to report.

Sensitivity Analysis (Integrated Model):

Nothing new to report.

Support Guar Manuscript Development:

Nothing new to report.

Guayule Scenario Analysis:

Nothing new to report.

Guayule Manuscript Development:

Nothing new to report.

Techno-economic and Life Cycle Assessment Results:

A variety of efforts were pursued as a part of this task with a summary presented below:

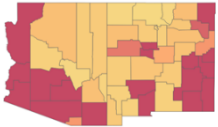
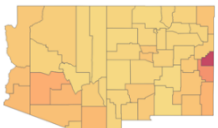
Guayule: The integrated model is currently being updated with bagasse to fuels modeling work. A first revision of the preliminary model for pyrolysis was made. The new, more detailed model is based on tail-gas reactive pyrolysis of guayule bagasse using the Aspen Plus software. Current work is focused on finalizing the TEA and LCA of the process model. These results will be compared to gasification and pelletization of bagasse in an upcoming journal article. In addition to the bagasse to fuels work, the CSU team is supporting data integration and uncertainty analysis efforts led by CSM. Support has included weekly reoccurring meetings and multiple technical working sessions.

Guayule Resin: The team supported revision of the guayule resin review article led by Catie Brewer's team. Support has included refining language, updating figures and charts, and providing reviewer responses.

Guar: The guar integrated model now has the complete sets of field trial data that the SBAR SUS team has obtained to date. The data has been entered and selection of all individual field trials yields propagation of appropriate data through the TEA results. Current work is focused on updating life cycle emissions data so that the field trial data can be propagated through the LCA.

Water LCA: This quarter investigation of how to incorporate water within the LCA framework begun. A review of methods was performed and the Available Water Remaining (AWARE) methods were selected. Current work is focused on obtaining the necessary data to perform Water Scarcity Footprints (using the AWARE methods) including spatial and temporal irrigation regimes for all crops within the integrated model.

Table 11. Current method evaluation for SBAR water LCA. Water Scarcity Footprint = water use X characterization factors.

Method	Advantage	Disadvantage	Characterization Factors
Availability Minus Demand (AMD) Method	Standard method selected by founding organization	Does not account for D>A, cutoff limits resolution in arid regions (38% set at 100)	
Demand to Availability (DTA) Method	No truncation, accounts for D>A, increased resolution for arid region	Results not directly comparable to standard method (case study limited)	

Data Integration:

Experimental data integration represents a critical need for the sustainability team. CSU continues to support CSM with seamless integration of data into the integrated models. Care is being used to ensure raw agricultural data is not accidentally disseminated by imbedding data in uncertainty distributions. Additionally, data gaps are being identified with changes to the integrated model being implemented.

Validated Integrated Model, Including Alternative Crops:

Two minor modifications were made recently to the integrated models. As changes are required these models are updated in concert with the Sustainability Team needs.

Facilitate and Foster Relationship between Tribal Farms and Bridgestone:

Continuing to assist in securing experimental plots on at least two tribal farms. 1) Connect Bridgestone and CRIT farms for experimental acreage agreement, establish introduction meeting and started contract negotiations 2) Connecting Bridgestone and Fort McDowell Farm or Ak Chin Farms for experimental acreage agreement. Started the conversation, but still trying to establish an agreement that will work for both parties. This continues to be a difficult task, but will keep trying.

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	Scenario analysis	Generate results of scenario analysis	1 Apr 21
		Present results of scenario analysis at conferences for feedback	1 Apr 21
		Submission of manuscript based on field trial data	1 Jul 21

Scenario Analysis:

The CSU team continues to work on the integrated models, leading the guar modeling effort and supporting CSM as they lead the guayule modeling efforts. Data integration work has been focused on understanding data gaps in the field trail data and working with CSM and field trail researchers to fill in these gaps. This has resulted in the need for additional modeling in the integrated models.

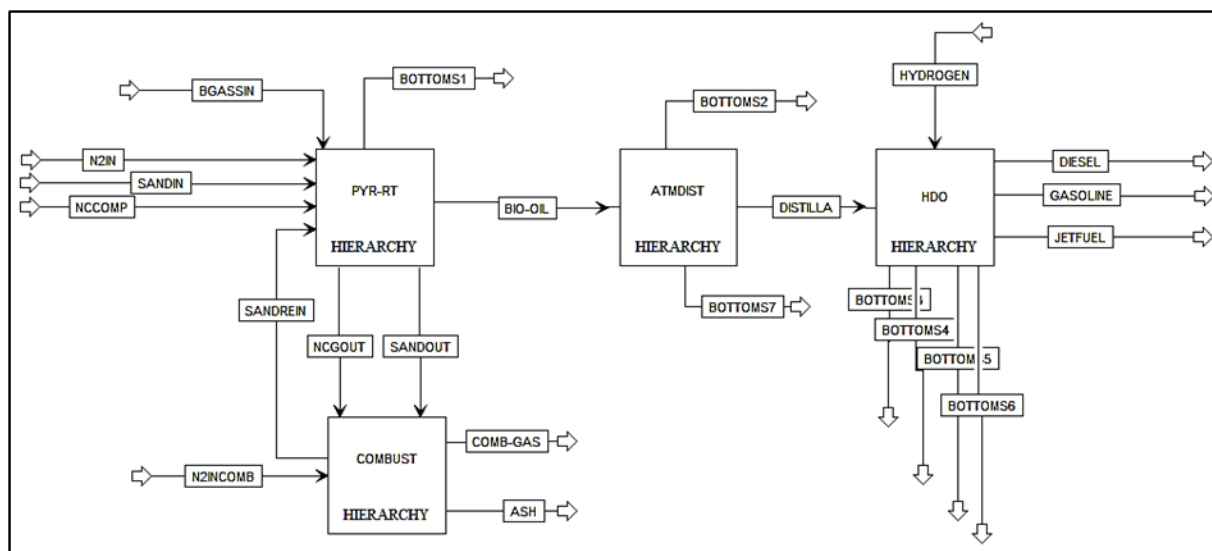


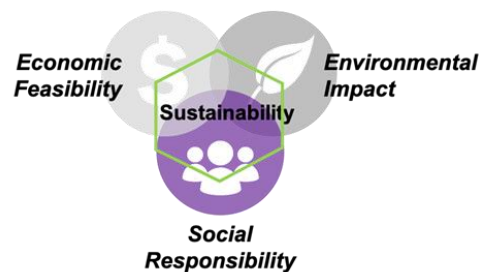
Figure 16. Bagasse to fuels diagram.

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	Qualitative social sustainability manuscript	Complete manuscript: modify existing manuscript to focus on “hot spot assessment” of guar and guayule	31 May 21

Qualitative Social Sustainability Manuscript:

The manuscript “Social Sustainability of new bio-based feedstocks in the Southwest” has been submitted to *The International Journal of Social Sustainability in Economic, Social, and Cultural Context*.



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	30 Apr 21
		Manuscript submitted to peer review journal	30 Apr 21
2 Fan	Apply integer optimization approaches to design smart farm production plan/scheduling	Computer codes and programs with embedded optimization models and algorithms	31 Aug 21
3 Fan	System-level model/algorithm generation for decision support for guar and guayule	Data/model/algorithm shared for Yr4 research (integration of 3 decision modules)	31 Aug 21

Comprehensive Sustainability and Regional Economics Analysis:

We have continued to gather information to model the guayule and guar supply chains, for the following states (or target areas):

- In Arizona – 15 counties
- In New Mexico – 33 counties
- In Texas – 254 counties

To model specific industry requirements for the guayule supply chain, preliminary information of the historic weather has been gathered as well. The guar and guayule supply chain models, with the integration the environmental and social impacts has been extended based on Year 3

results to meet the new scope and requirements for more general areas. The coding of such models is being updated accordingly as well for the targeted areas.

Integer Optimization Approaches for Smart Farm Production/Scheduling:

Based on the preliminary results of Year 3, Visual Basics for Applications (VBA) and CPLEX have been identified to integrate the three optimization models for guar and guayule supply chains. The three optimization models can be integrated directly through CPLEX using C++ and we have started trials for the integration. A potential structure for part of the upstream supply chain model is presented below.

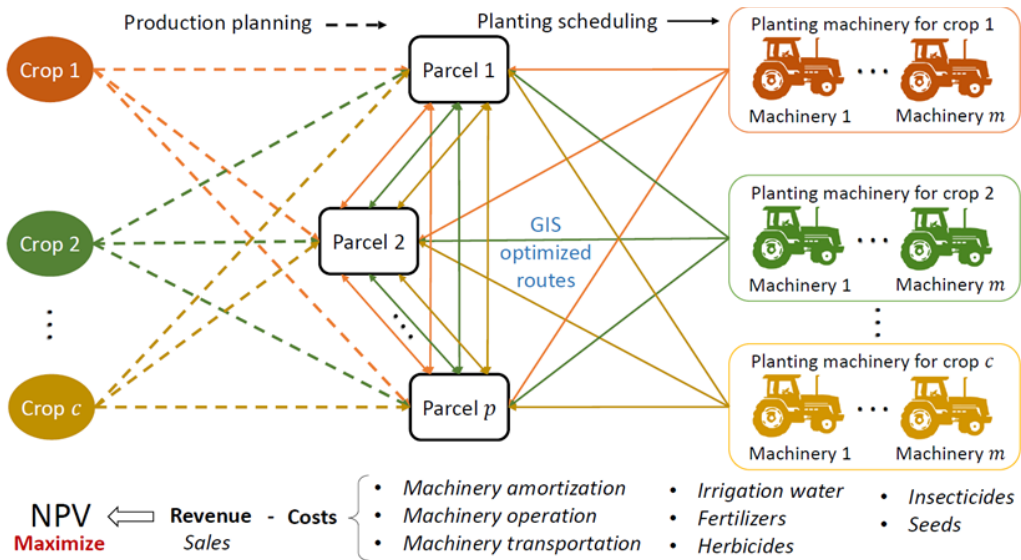


Figure 17. Upstream supply chain model structure.

System-level Model/Algorithm for Decision Support:

A Python-based platform is being analyzed as a potential candidate to integrate the GIS with the transportation system-level modeling and the feedstock logistic optimization modeling. Geoprocessing tools can be created and coded to address the specific requirements for the system-level model. We have started initial trials for the creation of geoprocessing tools for ArcGIS Pro based on Python using Spyder and CPLEX as show below.

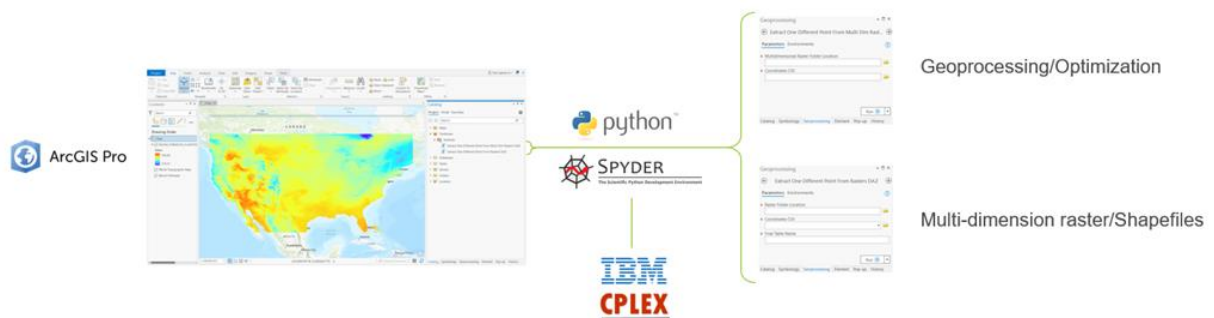


Figure 18. Geoprocessing/optimization - software diagram.

EXTENSION & OUTREACH

Project Coordination: Dr. O. John Idowu (New Mexico State University) and Blase Evancho (University of Arizona) continue to serve as the co-leads for the Extension & Outreach working team. When the larger Education and Extension & Outreach components jointly meet, Dr. Idowu and Evancho work with Dr. Chavarria to draft meeting agendas. Cara Duncan Shopa (UA) assists with coordinating meeting details as well as 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: All extension activities were delayed or not done in 2020. Extreme drought also contributed for the failure. In spite of all odds, we conducted all field trials, collected data and harvested all of them. We have collected videos and time lapse videos of guar harvest and growth in response to irrigation strategies. Video editing and final product will be produced when we get some help, either as a graduate student or technician.

Evancho: While progress is still being made in several areas the impacts have been greatly reduced due to implications from COVID-19 protection protocols and will continue to be impacted until resolved.

Grover: No funding was obtained specifically for extension work this year. The guar station trial was already planted at Lyendecker Plant Science Center, Las Cruces and recently harvested. Face-to-face interactions have been restricted due to COVID.

Idowu: Due to COVID-19 pandemic restrictions, many fall activities such as field days/conferences were cancelled and this affected the outreach of SBAR in New Mexico. The Extension and Outreach Newsletter was due to be released in December 2020, but some final edits that were needed prevented a timely release. The Newsletter will be released in January 2021 instead.

Morris: We are still being impacted by Covid 19 restrictions that have caused delays. Though still impacted, we have strategized and made some adaptations to build off of parallel efforts (e.g., the ambassador program piggy-backing on the STEM YOUiversity and partnering with the former *Project Puente* team).

I am anticipating significant trouble attracting both intern candidates and hosts due to workplace limitations precluding this from happening. However, we are planning nonetheless. Beyond just planning, we are trying to think beyond the pandemic. For example, we have engaged the College of Agriculture and Life Science career center so that the concept of an internship can become part of the culture of the college and that our work can have sustainability.

Rock: We have maintained some tasks, but others are falling behind. Brassill has continued working with 4-H STEM leader Nick Morris. She and Morris will continue to coordinate the recruitment of student interns and faculty mentors with the 4-H objectives in mind when it is safe to do so.

We began the quarter working under phase 2 guidelines. However, recent events have shifted the University guidelines back to phase 0 where we cannot safely bring student interns to campus. Because our grant objectives specifically target in-person training and education for student interns, our project team is waiting patiently to bring students back to campus when it is safe to do so. With that in mind, our team is currently reaching out to faculty mentors to identify projects that could be completed online or remotely. Ideas such as creation of fact sheets and data analysis have been proposed as possible alternatives.

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

Seavert: COVID-19 pandemic has stalled in-person meetings; however, we continue planning for online programs.

Teegerstrom: COVID-19 is still very active and restricting extension and in-person meetings, but programming efforts continue through online options.

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 Dec 20
		Create videos of guar germination and growth	31 Dec 20
2 Angadi	Guar agronomy research	Gather/analyze data; develop peer-reviewed article on N and P fertilization study	31 Mar 21
3 Angadi	Guar critical stage irrigation study	Produce report on guar crop growth based on irrigation management	28 Feb 21
4 Evan	Produce guayule newsletter articles	At least 2 guayule articles drafted and published – targeting AZ growers	31 Aug 21
5 Evan	Develop outreach documents for guayule	Background and introduction of guayule	31 Apr 21

		Guayule yield by variety	30 Jun 21
		Plant population management	30 Jun 21
		Guayule weed management	31 Aug 21
		Infographics for use in materials	31 Aug 21
6 Grover	Establish guar trial and showcase guar as potential crop in NM	Collect data; results synthesized	30 Jun 21
		Generate peer-reviewed publication	31 Aug 20
7 Grover	Guar demonstration	Identify farm willing to host a demonstration field trial	31 May 21
		Plant demonstration trial	31 Jul 21
		Harvest demonstration trial	31 Dec 21
8 Gutierr	Develop producer-level partial budget analysis for guar and guayule	Generate 3 extension bulletins	31 Mar 21
9 Idowu	Travel to conferences	Present SBAR info/materials at 4-5 grower commodity conferences	31 Aug 21
10 Idowu	Establish guayule and guar trials in Las Cruces, Los Lunas, Clovis, and Tucumcari, NM	Showcase trial experiments at field days	31 Aug 21
		Gather data/synthesize results (toward generating an Extension bulletin)	31 Aug 21
		Generate trial summary (published on SBAR website)	31 Aug 21
11 Idowu	Establish on-farm demonstration trials	Collect and summarize planting data for on-farm trials	31 Aug 21
		Final report prepared for website	31 Aug 21
12 Idowu	Newsletters to inform stakeholders	Distribute fall newsletter	31 Dec 20
		Distribute spring newsletter	31 Jul 21
13 Idowu	Design/schedule/implement E&O evaluation	Fall evaluation data gathered	31 Dec 20
		Spring evaluation data gathered	31 May 21
		Summer eval data gathered	31 Jul 21
		Eval info synthesized; report generated	31 Aug 21
14 Miller	Develop Extension programs/reports for guar and guayule	Finalize 3 extension bulletins: guayule and guar production costs; guar market/transportation; farm-level scenarios	31 May 21

15 Seav	Validate/Revise Sensitivity Analysis Model for use in Extension meetings; Participate in grower workshops	User manual for model targeting Extension educators Workshop hosted (Title: The Costs and Benefits of Producing Alternative Crops in NM and AZ: Guayule and Guar)	31 Oct 20 30 Nov 20
16 Seav	Develop percentage of returns for tenant-landowner contributions	Draft Extension publication re: equitable lease arrangements; target audience: SW tenant/landowners	31 Aug 21
17 Seav	Demonstrate trade-offs of machinery ownership to custom hiring operations	Draft Extension publication re: machine needs and options for guayule and guar	31 Aug 21
18 Seav	Develop enterprise budgets for all crops in Sensitivity Analysis Model	Generate six Extension cost of production bulletins for AZ and NM Generate one Extension cost of production bulletin on growing hemp Hemp budgets accessible online via <i>AgBiz Logic</i>	31 Mar 21 31 Aug 21 31 Aug 21
19 Teeg	Generate an interactive farm-level economic and financial model (guar and guayule)	Validate and revise BENCO Model for use in Extension/Outreach meetings Develop PPT/guide for using the farm-level economic financial mode	31 Jul 21 31 Jul 21
20 Teeg	Participate in Extension meetings; disseminate economic info for guar and guayule	Provide 2 presentations to growers in NM Provide 2 presentations to growers in AZ	31 Aug 21 31 Aug 21

Guar Photographs and Videos:

Extension and outreach was affected the most by COVID-19. This quarter, I had no help. People helping in the project, a research scientist, a graduate student and a temporary technician got a new job or graduated earlier in the year. Due to budget cut and hiring freeze, I could not replace both research scientist and graduate student. After a long delay, I got approval for a lab tech during the quarter. However, I am not getting suitable applicants in the last two months.

In spite of that, we made some progress in shooting guar harvest videos and guar crop growth videos with the help of Mr. P. Singh. We will work on video editing, when we get some help. With help from other programs and Dr. John Idowu's team, we harvested most of our field trials including demonstrations or extension oriented trials. Processing samples and data collection is still going on.

Guar Agronomy Research:

Guar N and P fertilization study was harvested with the help of Darien Pruitt and Dr. Mohammed Omer. Samples were dried, weighed and threshed. Data on seed yield is being recorded.

Guar Critical Stage Irrigation Study:

Nothing new to report.

Produce Guayule Newsletter Articles:

Nothing new to report.

Develop Outreach Documents for Guayule:

Nothing new to report.

Showcase Guar as Potential Crop in New Mexico:

Trial was harvested and the plant samples were collected for threshing and seed yield data collection. Single plant samples were also collected and will be manually threshed for collecting seed yield attributing characteristics.

Guar information for SBAR website is being updated and will be shared within the guar extension group and will be uploaded on the website in the coming months as decided at the EEO meeting.

Two extension manuscripts as co-author are currently in revision. (1) Laje et al., Natural Products in the Desert Southwest: Guayule (*Parthenium argentatum*) and Guar (*Cyamopsis tetragonolobus*); (2) Khanal et al., Enterprise Budgets for Guar Production. Another extension manuscript focusing on guar production practices is being prepared.

Guar Demonstration:

Due to the ongoing pandemic, it was conveyed by the SBAR Leadership team not to pursue these goals. Efforts will be devoted in collaborating with other members of extension team and partners.

Develop Producer-Level Partial Budget Analysis for Guar and Guayule:

Enterprise budgets and narrative detailing the cost and returns of guar and guayule. Publications include: (1) Guar and Guayule Cost of Production Fact Sheet; (2) Guar peer review complete; (3) Guayule peer review pending. Under final review: bulletins to answer producer's questions on sustainability and production of guar and guayule in southern New Mexico.

Travel to Conferences:

A presentation on N & P guar trial was giving at the Agronomy Society Annual International Conference in November 2020.

Establish Guayule and Guar Trials in New Mexico:

All of the on-station N & P guar trials were harvested at all the 4 trial locations. Processing of harvest products has continued in the laboratory. Data collation and analyses is also on-going. Results from all locations will be compiled by the end of January 2021.

Establish On-Farm Demonstration Trials:

Nothing new to report.

Newsletter to Inform Stakeholders:

Preparation of the Extension and Outreach Newsletter (volume 2 Issue 2) commenced during this quarter and will be released in January 2021.

Develop Extension Programs/Reports for Guar and Guayule:

New task to begin in January 2021.

Design and Implement Extension & Outreach Evaluation:

Nothing new to report.

Validate Sensitivity Analysis Model for use in Extension/Outreach Meetings:

Many changes were made to the existing sensitivity model to accommodate a new format - operational budgets - for Extension bulletins as this modification delayed the user-guide for Extension educators. COVID continues to delay workshops for producers, but the model is ready for extension use in 2021. Working with Economic Team to confirm meeting dates for online presentations. Future of in-person presentations depends on COVID-19 virus restrictions.

Develop Percentage of Returns for Tenant-Landowner Contributions:

In the previous sensitivity model, the budgets were developed in the resource input format, which is ideal for establishing equitable leasing for guar and guayule. This format still exists and establishing leases for these crops as per a crop share lease is 75 percent complete. A cash rent lease is delayed into Q1.

Demonstrate Trade-Offs of Machinery Ownership to Custom Hiring Operations:

Users can now enter custom rates into the sensitivity model to measure the profitability tradeoffs of machine ownership vs custom hiring operations to complete field tasks. An Extension publication is on target to be completed in 2021.

Develop Enterprise Budgets for all Crops in Sensitivity Analysis Model:

Guar enterprise budget reviewed by NMSU and waiting input from Guar Resources. Bridgestone approved guayule budget to be reviewed by U of A for publication. New publication format is near completion and budgets will be reviewed when this task is completed.

Interactive Farm-Level Economic and Financial Model (Guar and Guayule):

Continue to add and update relevant extension model scenarios and data. Now working on adding adjusted harvest information and cost.

Dissemination of Guayule and Guar Economic Information through Extension Meetings:

Continue to work with AZ and NM Extension team, with inclusion of new crop options with the current baseline for whole farm analysis to be used in the presentations during the extension/outreach activities. Future of this task depends on COVID-19 restrictions and preferred delivery method. One Extension publication for NM should be out soon with AZ following.

With the success of the virtual field day in October 2020, we anticipate additional meetings in the future in both states and reaching additional growers.

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 Dec 20
2 Angadi	Educate local growers	Establish guar demonstration on a local farmer's field	31 Dec 20
3 Evan	Hold workshops and present information to growers in Arizona	Host two presentations on guayule agronomic production and irrigation at regional extension events	31 Aug 21
4 Evan	Present guayule production information to Native American farming communities	Presentation to Native American Farm Boards	31 Aug 21
5 Evan	Communicate with AZ growers and producers	Maintain relationships with local growers to share SBAR/guayule information	31 Aug 21
6 Fields	Track Grower Extension Team activities monthly	Compiled contact data totals submitted quarterly	31 Aug 21
7 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 21 31 Aug 21

Educate Local Producers about Guar:

Working on guar web page. Efforts will be made to convert some of the data produced into extension literature during 2021.

Establish Farm Demonstration Site in New Mexico:

We could not recruit farmers to conduct a field scale demonstration of guar in 2020 due to COVID and extremely dry season. We will make an effort to conduct demonstrations in 2021. I have started contacting people.

Grower Workshops in Arizona:
 SBAR big-picture topics and guayule production was presented at Pinal County Extension Day to community members. [78 attendees] Guayule Grower field day was held virtually in collaboration with Arizona Cooperative Extension/Arizona Pest Management Center and Bridgestone America. [~105 attendees]



Photo 11. Blase Evancho discussing guayule production with a Pinal County resident at a Drive-Thru Farm Field Day.

Guayule and Native American Communities:

Native American communities still lack interest in guayule and have seen exceptionally high impacts from the coronavirus further complicating our ability to deliver information.

Communications with Arizona Growers:

After a short period allowing for some engagement with our stakeholders, we have once again been restricted to virtual interactions since approximately Thanksgiving. Virtual site visits with grower groups are still occurring and have included attendance at all 5th Water Management Plan meetings, development of the new protocol for irrigation management BMP program in the 5th Management Plan, AZ Cotton Research and Protection Council Meeting, as well as several irrigation districts, and ag industry meetings.

Track Grower Extension Team Activities Monthly:

The table below quantifies outreach by event during Q4 2020. In AZ, two events occurred in October. In NM, all events (which could include field days, conferences, regional extension meetings, etc.) were cancelled due to COVID. No personal contacts were made.

Table 12. Outreach events conducted during Q4 2020 in Arizona and New Mexico.

	Event	Date	Number participating
AZ	Bridgestone Field Day (Information share between SBAR researchers with various stakeholders)	10/10/20	105 (adult professionals)
	Pinal County Extension Day (general SBAR information and outreach)	10/3/20	78 (33 youth/45 adult)
NM	None	N/A	0

Grower Workshops in New Mexico:

Two poster presentations delivered and abstracts published on guar at 2020 ASA-CSSA-SSSA Annual Virtual Meeting.

Two students were taught *Special Problems/Special Topics* (AGRO 449/AGRO 500), where the students participated in hands-on research work in the SBAR guar project. (Total = 2 students)

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Fields	Design/schedule evaluation tools, protocols, and metrics for all Extension & Outreach activities	Fall tools developed/refined; evaluation data gathered Spring tools developed/refined; evaluation data gathered Summer tools developed/refined; evaluation data gathered Data synthesized; evaluation report generated	31 Dec 20 31 May 21 31 Jul 21 31 Aug 21
2 Gutierr	Develop/improve SBAR 4-H Camp curriculum	Adapt camp curriculum for use in NM (train-the-trainer and FFA STEM curriculum)	31 Mar 21
3 Gutierr	School enrichment and 4H Camp/FFA activities	Plan/Host 4 SBAR Day camps targeting Hispanic and Native youth Plan/Host 12 SBAR school enrichment events Host 3 FFA teacher trainings on FFA/SBAR activities	31 Aug 21 31 Aug 21 31 Aug 21
4 Miller	Provide training for FFA teacher and 4-H Extension Agents	Host workshop for FFA teachers to support Agri-Science fair students	28 Feb 21
5 Miller	Finalize SBAR/FFA activities	Separation of Mixture Plant Chemicals that Fight Free Radicals Thin Layer Chromatography of Pepper Pigments	31 Mar 21 30 Jun 21 31 Aug 21
6 Miller	Lead creation of 4-H youth science project development re: bio economy	Create formal proposal for 4-H Leadership Initiate 4-H curriculum review process	31 Mar 21 31 Aug 21

7 Miller	Co-lead development of <i>Guardians of the Biosphere</i> curricula and activities	Draft bioeconomy-related 4-H project curricula for grades 5-7; initiate curriculum review	31 Aug 21
8 Morris	Adapt existing curriculum for 4H program	Two existing 4H curricula adapted for SBAR topics (bioeconomy)	15 Nov 20
9 Morris	Develop county level STEM Ambassador Program (SBAR-related)	Host focus group meeting with STEM Camp Counselors in June Ambassador guidebook for county implementation	31 Dec 20 31 Dec 20
10 Morris	Design STEM volunteer training program; recruit volunteers	Recruit 5 STEM certified volunteers Host 3 STEM volunteer trainings	31 Dec 20 31 Dec 20
11 Morris	Develop STEM internship program plan, recruitment plan, evaluation plan	Completed internship program plan, recruitment plan, and evaluation plan	31 Jan 21
12 Rock	Develop SBAR internal factsheets on <i>Project Puente</i>	Generate <i>Project Puente</i> resource document(s) for SBAR faculty	28 Feb 20
13 Rock	Recruit students for summer <i>Project Puente</i> internships	Update application materials to highlight on-going SBAR research opportunities Recruit 6 students for Yr3 cohort of <i>Project Puente</i> interns	pending
14 Rock	Recruit faculty mentors for summer <i>Project Puente</i> internships	Recruit 5 faculty mentors for Yr3 cohort of <i>Project Puente</i> interns	pending
15 Rock	<i>Project Puente</i> student project development and deployment	Work with SBAR faculty to identify appropriate internship projects (research and extension) Facilitate SBAR internship projects; final poster presentations highlighting student work	pending
16 Rock	<i>Project Puente</i> case study video	Design and develop short video highlighting student/mentor experiences for future training needs	pending

Design and Implement Evaluation Tools:

During the Q4 of 2020, the primary tasks related to the evaluation of the EEO components of the SBAR project were centered around attending team meetings to follow process and outcomes, determine evaluation needs given project shifts, and develop final year 4 evaluation plan.

Grower-Focused Extension – For the grower-focused extension team, they continue to face COVID related challenges in regards to their outreach efforts. In October, Bridgestone offered/collaborated on a Virtual Field day and an event was held in Pinal County, AZ. The grower-focused extension group has continued to work on website development, but are prioritizing this for Q1 2021.

Youth Development Extension – Efforts over Q4 were largely around website development and planning for the project year overall and summer activities. In AZ, a summer internship program is being developed for spring recruitment of interns and hosts. They are seeking to identify SBAR researchers who are interested in hosting an intern. In NM, they are exploring further development of FFA connections and dissemination of SBAR materials.

Adapt SBAR Curriculum for 4-H and FFA Camps:

Completed the second SBAR/FFA lesson plan “Thin Layer Chromatography (TLC) of Pigments from Chile Peppers”, along with supporting PowerPoint and video. *These materials still need editing.* Started third SBAR/FFA Lesson plan “Plant Chemicals that Fight Free Radicals.”

Completed three PowerPoint presentations as part of the supporting materials for the SBAR/FFA Lesson Plans.

SBAR 4-H Youth Outreach: Shared the July 2020 SBAR E&O Newsletter with NMSU. Stephanie Hofacket, Coordinator for K-12 Science Instruction Challenger Learning Center, Las Cruces Public Schools, and with the Executive Director of the Asombro Institute for Science Education.

SBAR 4-H Day Camps or Mini-Camps:

Submitted write-up of the NMSU/SBAR/E&O outreach 4-H Project Day and 4-H Leadership Retreat (Opening the Door to Your Future) activities for the July 2020 SBAR Extension & Outreach Newsletter.

Training for FFA Teachers and 4H Extension Agents:

New task to be started in January 2021.

Finalize SBAR/FFA Activities:

New task to be started in January 2021.

Create 4H Youth Science Project Development re: Bioeconomy:

New task to be started in January 2021.

Develop *Guardians of the Biosphere* Curricula and Activities:

New task to be started in January 2021.

Adapt Existing Curriculum for 4H Program:

We have selected three curriculum plans: Arid Lands, Agriculture in Arid Lands, and Sustainable Bioeconomy (in development). These lessons are now in a draft stage. In addition to the Arid Lands curriculum, I am also working with faculty and fellows from New Mexico State

University to adapt a “*Guardians of the Biosphere*” afterschool experience to a 4H afterschool program.

Develop County-Level STEM Ambassador Program (SBAR-related):

We only had one youth sign up for the original Ambassador training program. We decided to regroup and strategize for more effective implementation and determined that it would likely not be successful if kept separate from the other STEM YOUNiversity activities. We decided thus to connect it to the Spring opportunities.

Outcomes, outputs, and session themes have been determined. Ambassador training sessions are planned for February, March and April to coincide with STEM YOUNiversity programming. Youth who have participated or are participating in train-the-trainer experiences are eligible to serve as Ambassadors.

Additionally, Arizona 4H was selected to participate in the Ag Innovators Experience and will train 20 youth for program leadership. Once trained, these youth will be added to the county STEM Ambassador program.

Design STEM Volunteer Training Program; Recruit Volunteers:

Twelve new youth leaders have been STEM content trained since October by the Arizona 4H STEM. They will all be invited to engage in the STEM Ambassador experience. The Arizona 4H team is assessing the need for creating an Arizona 4H STEM volunteer training.

Develop STEM Internship Program, Recruitment, and Evaluation Plans:

The Arizona 4H STEM internship teamed with the former Project Puente internship program. Both programs are currently being advertised for both interested intern candidates and internship hosts. The Junior Internship is a 60-hour experience focused on building an understanding, education, skills, and dispositions necessary for success within a particular STEM career. The Senior Internship (formerly *Project Puente*) is a 200-hour research experience.

In December we began conversations with the College of Agriculture and Life Science Career Center to assist in building sustainability of this project.

Internal Factsheets on *Project Puente* Internships:

We continue to develop new resource documents for SBAR faculty on expectations of mentors, expectations of students, timelines, reporting structure, among other topics.

Project Puente Internship Student Recruitment:

We recently disseminated content 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 (as appropriate). Our initial goal was to increase participation to a total 6 student interns and associated SBAR faculty to participate in the project in year three.

Project Puente Internship Faculty Recruitment:

As stated in previous reports of 2020, during the last three reporting periods the extension team has continued to work to recruit additional SBAR faculty to participate in *Project Puente* for

Summer of 2020. However, due to COVID-19 concerns as well as university shut down, our team switched gears to offer internship during the 2021 semesters in two alternative forms.

Project Puente Student Project Development and Deployment:

Nothing new to report.

Project Puente Case Study Video:

The extension team is continuing with the plan to create a short case study video to highlight the success of the program for broad dissemination once internships are deemed 'ok'.

EDUCATION

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

Issues/Risks:

Brewer: Progress was made on the lesson plan development such that the identified five lesson plans for Theme 5 should be completed by the end of 2021 Q1.

Ongoing modifications to public school course delivery methods due to the COVID-19 pandemic have limited Fellow participation in classroom activities. Las Cruces Public Schools went from planning to being hybrid to being completely remote through the fall semester. Teachers spent the majority of their time and energy coordinating lessons across the district to teach new content to meet standards, shifting to use of the Canvas delivery platform, and tracking student participation. While fellows reached out to their partner teachers, no meaningful SBAR lesson implementation or vetting was accomplished this quarter.

In December, the EEO team revisited the decision in September to delay teacher recruitment and extended the delay into the spring, likely for the remainder of the school year. Instead, the time will be used to populate the five themes with complete lessons and to gauge the level of participation possible with teaching format decisions.

In December, Gutierrez announced his upcoming retirement in May 2021. H, Idowu, and Brewer met with Ogden and Rogstad to discuss options to involve a new faculty member in Ag. Business/Economics at NMSU, Frannie Miller, in the youth outreach efforts in NM and to capture the activities through the Guardians of the Biosphere (GOB) afterschool program in Years 2 and 3. The decision was made that Miller would work with Brewer, Morris from UA, and the NM Fellows to develop the GOB and other activities into a 4H special interest club curriculum. Miller and Usrey will focus on the 4H activities, while Brewer will focus on the formal lesson plans. Revised statements of work for Year 4 will be submitted by February 1, 2021.

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	With Education Team, create and deliver online teacher professional development modules	Online professional development modules for SBAR and SBAR lesson/activity resources	31 May 21

2 Brewer	Recruit and train SBAR Fellows and Teachers for 2020-2021 school year	Identify 2 new NM SBAR Fellows and any replacements, as necessary	31 May 21
		Identify 2 new NM SBAR Middle school teachers	31 May 21
3 Chav	Plan/Design/Coordinate Fall 2020 and Spring 2021 SBAR Fellow seminar for hybrid approach	Plan Fall 2020 semester digital content	31 Aug 20
		Plan Spring 2021 semester digital content	31 Jan 21
4 Chav	Visit classrooms for observations (delivery of SBAR content)	Implement Fall teacher observation	30 Nov 20
		Implement Spring teacher observation	30 Apr 21
5 Fields	Design/Schedule classroom evaluation tools, protocols and metrics for all Education activities	Fall tools developed/refined; evaluation data gathered	31 Dec 20
		Spring tools developed/refined; evaluation data gathered	31 May 21
		Summer tools developed/refined; evaluation data gathered	31 Jul 21
		Data synthesized; evaluation report generated	31 Aug 21

Create/Deliver Online Teacher Professional Development Modules:

Nothing new to report.

Recruit and Train SBAR Fellows and Teachers (2020-2021):

Brewer and the NM Fellows worked with the Education team and the AZ Fellows to develop lesson plan goals for five themes related to SBAR, each to have at least five fully complete lesson plans. NM Fellows were tasked with lesson plans for Theme 5 related to chemistry, engineering, and processing (to complement Theme 3 on bioproduct types and applications).

Singh and Pruitt maintained contact with their respective partner teachers (Daugherty and Strand). Pruitt met with Strand to discuss options for incorporating SBAR content into her class Canvas page. Daugherty was able to visit the Clovis Ag Science Center in early fall to tour the demonstration plots and to see the drone crop monitoring work.

SBAR Fellow Seminar (Fall 2020 / Spring 2021) / hybrid approach:

The Fall 2020 semester took place with a weekly Seminar course on Wednesdays from 1-2PM.

Our COVID Pivot: Because the majority of the SBAR Fellows are still not able to work with teachers due to COVID, our focus has been on digital lesson development. Tenzin Phakdon

has been able to continue some of her work with Valentina Andrews and Felecia Hinton-Causey at the Santa Rosa Ranch School (Tohono O'odham Nation).

The focus of the end of the Fall Seminar has been:

- Refining selected lesson plans with feedback from the cohort, Chavarria, Knox and Anderson.
- Exploring the components of the lessons that will make them unique such as:
 - o Emphasizing local connections with the lessons
 - o Focusing on arid lands
 - o Incorporating aspects of culture, arts, and interactive activities
- Getting outside input from experts on their lesson plans and interview approach (Ali Yaylali) from the extended SBAR team including Ali Rogstad and Nick Morris.
- Exploring digital and zoom strategies for engagement. This included a presentation from Earyn McGee on her successful use of social media for communicating science.
- Discussion and reflection on their experience as an SBAR Fellow.

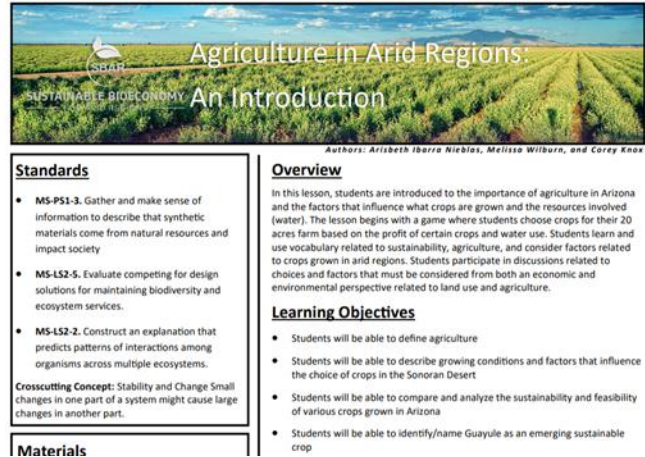


Figure 19. Screenshot of SBAR curriculum developed by SBAR Fellows.

Each Fellow refined one lesson and began work on a second lesson plan. Two lessons from this in-depth process are in the final copy-editing stage to prep for digital posting.

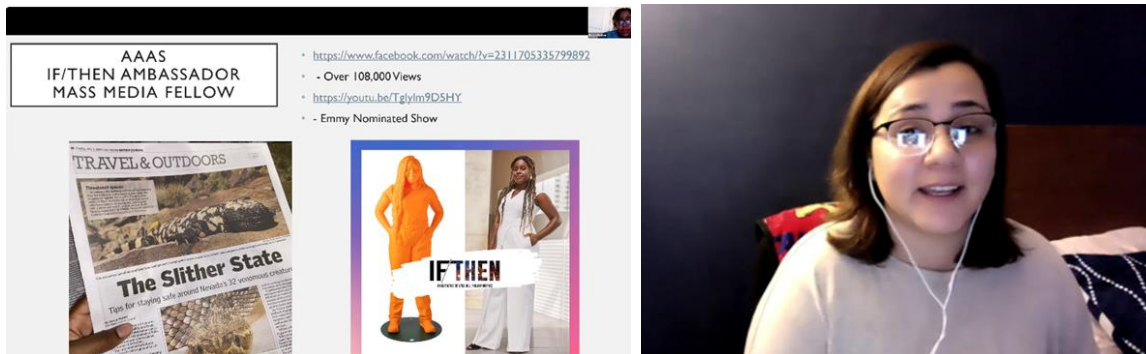


Figure 20. SBAR Fellow, Karina Martinez, participated in training for how to use digital strategies to communicate science.

Classroom Observations (Delivery of SBAR Content):

While we have not been able to visit schools in person, we have worked on several efforts to broaden our connections during this quarter, including:

- Knox making a presentation to 4H about the SBAR resources being developed and the potential for SBAR Fellows to provide presentations and activities via online technologies.
- Spearheading the development of a monthly Education-4H-FFA meeting to explore cross-pollination. This meeting has provided support to the NM team as they clarified the focus of their SOW and allowed us to be more strategic in our collaboration. Further support for NM involved: Chavarria, Knox, and Anderson meeting with F. Miller to have the NM Fellows work on the *Guardians of the Biosphere* materials. Knox has also provided support to L. Rodriguez-Uribe in giving feedback on her FFA activities.
- Supporting Fellows in applying for conference presentations, fellowships, and scholarships. Such as when the team worked with A. Ibarra on presenting her lesson, “Exploring Bioproducts: Glue for Piñatas” to 5 groups of students, grades 6-8, at the 2020 American Institute of Chemical Engineers (AIChE) K-12 STEM Outreach Competition. Ibarra won 2nd Place in the Professional/Combined category for her lesson and spread awareness of the work of SBAR Fellows.
- Collaborating with the SBAR EEO team through two mini-retreats and developing two SBAR highlights.
- Participating in a networking meeting with SPARC to explore lessons learned from our respective grants.
- Identifying conferences to present at in the future.

Design and Implement Classroom Evaluation Tools:

During the Q4 of 2020, the primary tasks related to the evaluation of the EEO components of the SBAR project were centered around attending team meetings to follow process and outcomes, determine evaluation needs given project shifts, and develop final year 4 evaluation plan.

For the Education team, efforts in AZ continue to center primarily around curriculum refinement and consolidation (ED team and graduate fellows) into themed units as well as the professional development seminar for graduate fellows. In NM, curriculum is still under development that is targeted towards FFA partnerships.

Through a series of meetings with members of the EEO team, we discussed and co-developed the evaluation plan described below. Given the changes that COVID has brought in terms of the timing of some of the planned activities, it necessitated a fairly significant shift in the evaluation plan that was previously developed and was more dependent on participant data (teachers, students, campers, etc.). The team saw value in a deeper exploration of the graduate fellow experience in order to identify best practices and inform the field about the co-teaching, curriculum design and professional development activities with graduate fellows.

The evaluation plan includes the following components:

Graduate Student Surveys and open feedback: At the beginning of the project, a survey was developed ask fellows to rate their confidence in completing skills associated with their project role. This survey was given again following the second summer professional development experience. The same confidence scale will be given to the fellows who have been involved with the program for at least one year, including those who have completed their experience where possible, to assess changes. Several open-

ended questions will be added to the survey that were not previously asked. Some areas for exploration include:

- How much of the change in confidence in skills can be attributed to the professional development provided by SBAR staff?
- How do the lessons developed reflect the PD provided?
- For those fellows with previous education outreach experience, how has the SBAR experience expanded their thinking, or changed their processes when developing and implementing lessons?
- For fellows with English as a second language (n=2), how has this experience impacted language skills, particularly in regards to explaining complex science concepts in more simple language?
- How has the fellowship affected their work as a scientist? Or for those who have graduated, their career direction?
- Has SBAR contributed to their awareness of social justice or access issues?

A select group of fellows will be interviewed to provide additional detail and context. The evaluation will also document the elements of two slightly different approaches for implementing the SBAR project by the EEO team. In NMSU, the EEO team, including the graduate fellows, were largely playing the role of SBAR researcher and education/extension personnel. In Arizona, there was a separation of those roles, even among graduate fellows who were largely not involved in SBAR disciplinary research but rather only the teacher/fellow partnership. We will explore the challenges and opportunities of these approaches and emerging models through a few **case studies** among the teacher/fellow teams and their different experiences and outcomes. In Santa Rosa, AZ, the school serves Native American students and their approach was to designate a full day each week, ‘SBAR Friday’, where the students engaged in hands on activities and interacted with the teacher, graduate fellows, and other community educators around the SBAR project. In Clovis, NM there is a teacher participating whose school is in proximity to the research site where field demonstrations are planted. There is direct access to researchers and extension agents, and the graduate fellow who is a researcher. In Las Cruces, they implemented SBAR activities in an after-school environment. The curriculum and approach that was implemented, along with other SBAR developed lessons, are being integrated into an ongoing 4-H structure in AZ. Finally, some data will be collected on the internship experience, with specific details still in development. The specific tools and timeline are being finalized, but generally the case studies will be conducted throughout the remainder of project year 4 (implementation, data collection, transcription, analysis) for write up and publication/dissemination during year 5.

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

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Create/Refine SBAR digital resources	Ready-to-use SBAR lesson and activity resources available on SBAR website	31 May 21

2 Brewer	Support creation/refinement of 4H youth development activities based on Guardians of the Biosphere	Draft bioeconomy-related 4H project curricula for grades 5-7; initiate review process	31 Aug 21
3 Brewer	Communicate SBAR resources to NM educators	Participate in remote/in-classroom activities (as feasible) Developed recommendations for dissemination in Yr5	31 Aug 21 31 Aug 21
4 Chav	Edit Cohort 2 lessons and materials for online publication	Edit lessons Prep for digital posting	30 Nov 20 31 Dec 20
5 Chav	Support lesson plan design by teacher-Fellow partnerships	Fall lesson plans from each Fellow developed Spring lesson plans from each Fellow developed Advice and support NM teach as requested/needed Draft lesson plans from Cohort 2 teachers	30 Nov 20 30 Apr 21 31 May 21 31 Jul 21
6 Chav	Design, scheduling and implementation of evaluation tools and metrics	Fall evaluation data gathered Spring evaluation data gathered Evaluation report complete	31 Dec 20 31 May 21 31 Aug 21

Refine SBAR Digital Resources:

Usrey completed drafts of lesson plans for Combustion/Pyrolysis and for Fermentation. These are currently under review with Brewer and/or the UA team. He began compilation/organization of materials for the Transesterification (for biodiesel) lesson plan. Once that is completed, he will create a lesson plan on Separations/Extraction. Pruitt completed a draft of the lesson plan for Plant Polymers that is now under review with Brewer and the NMSU Fellows' team. Singh completed a draft of the lesson plan for Water for Food Crops to be included in Theme 4 (Sustainable Crops/Plant Science). He collected footage from the guar harvest and threshing in Clovis, NM, for use in the lesson plan presentations, and drafted videos for field presentations.

Create/Refine 4H Youth Development Activities Based on *Guardians of the Biosphere*:

New task to begin January 2021

Communicate SBAR Resources to New Mexico Educators:

New task to begin January 2021.

Cohort #2 Lessons and Materials:

Nothing new to report.

Support Lesson Plan Design by Teacher-Fellow Partnerships:

Nothing new to report.

Design, Scheduling and Implementation of Evaluation Tools and Metrics:

Chavarria, Knox, and Anderson met with J. Fields to discuss how to best evaluate the education component of the project. Areas that need to be included in evaluation are related to:

1. The need to reflect the complexity of lesson design for graduate students are creating lessons for the first time. (i.e., “How does the lesson development process inform the scientist you want to be?”)
2. The need to show how the SBAR Fellowship is impacting their role as scientists.

The Education team is working with Fields to develop a survey that will reflect their experience learning about lesson development, digital learning, and being a scientist.

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	

Development of Education Opportunities:

This task is complete.

The certificate program description is accessible on the SBAR website:

<https://sbar.arizona.edu/education/students/graduate-interdisciplinary-program>

AWARDS

Items appearing in blue font are new in this quarter.

2020

Ibarra Nieblas, A. *2nd Place, American Institute of Chemical Engineers (AIChE) K-12 STEM Outreach Competition.* Awarded in the Professional/Combined category for her innovative classroom lesson, “Exploring Bioproducts: Glue for Piñatas”. December.

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

Wilburn, M. *Middle School Science Teacher of the Year, Arizona Science Teacher Association.* Awarded for Arizona Competition. December.

2019

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

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

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

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

Wilburn, M. *Honorable Mention, Science Teacher Association.* Awarded in the Middle School Science Teacher of the Year Competition in Arizona. December.

PRODUCTS GENERATED.

September 2017 – December 2020

PUBLICATIONS, CONFERENCE PAPERS AND PRESENTATIONS

Items appearing in blue font are new in this quarter.

Publications

1. **Abdell-Haleem H.; Luo Z.; Ray, D. 2019.** Chapter 6. Genetic Improvement of Guayule (*Parthenium argentatum* A. Gray): An Alternative Rubber Crop. In: J. Al-Khayri (ed.). *Advances in Plant Breeding Strategies: Industrial and Food Crops*. Springer Nature Switzerland AG (Invited Book Chapter). p.151-178.
2. **Chen, F.; Bayat, H.; Jena, U.; Brewer, C.E. 2020.** Impact of feedstock composition on pyrolysis of low-cost, protein and lignin-rich biomass: a review. *Journal of Analytical & Applied Pyrolysis*, 147, 104780, DOI: 10.1016/j.jaap.2020.104780.
3. **Chen, F.; Brewer, C.E. N.D.** Conversion of protein-rich lignocellulosic wastes to bio-energy: review and recommendations for hydrolysis + fermentation and anaerobic digestion. [In Review]
4. **Chen, F.; Dehghanizadeh, M.; Audu, M.A.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2020.** Characterization and evaluation of guayule processing residues as potential feedstock for biofuel and chemical production. *Industrial Crops and Products*, 150, 112311. DOI: 10.1016/j.indcrop.2020.112311.
5. **Chen, Y.; Neilson, J.W.; Kushwaha, P.; Maier, R.M.; Barberan, A. 2020.** Life-history strategies of soil microbial communities in an arid ecosystem. *ISME J (International Society of Microbial Ecology Journal)* <https://doi.org/10.1038/s41396-020-00803-y>
6. **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.
7. **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.
8. **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, In Review]
9. **Cheng, F.; Dehghanizadeh, M.; Audu, M.A.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2020.** Characterization and evaluation of guayule processing residues as potential feedstock for biofuel and chemical production. *Industrial Crop & Products*. 150, 112311. <https://doi.org/10.1016/j.indcrop.2020.112311>
10. **Dehghanizadeh, M.; Cheng, F.; Jarvis, J.M.; Holguin, F.O. Brewer, C.E. 2020.** Characterization of resin extracted from guayule (*Parthenium argentatum*): A dataset including GC-MS and FT-ICR MS. *Data in Brief*, 31, 105989. <https://doi.org/10.1016/j.dib.2020.105989>. <https://doi.org/10.1016/j.dib.2020.105989>.
11. **Dehghanizadeh, M.; Mendoza-Moreno, P.; Sproul, E.; Bayat, H.; Quinn, J.; Brewer, C.E. 2021.** Guayule (*Parthenium argentatum*) resin: A review of chemistry,

- extraction techniques and applications. *Industrial Crops & Products*. 165 (2021) 13410. <https://doi.org/10.1016/j.indcrop.2021.113410>.
12. **Khanal, S.; Gutierrez, P.; Seavert, C.; Bhandari, P.; Grover, K.; Teegerstrom, T.; Blayney, D. N.D.** Enterprise Budgets for Guar Production. *New Mexico State University Extension Publication*. [In Review]
 13. **Khanal, S.; Robbs, J.; Gutierrez, P.; Seavert, C.; Teegerstrom, T.; Wang, S.; Dierig, D. N.D.** Guayule Enterprise Budget: Establishment, Growing and Harvesting. *New Mexico State University Extension Publicatio*. [In Review]
 14. **Khanal, S.; Seavert, C.; Gutierrez, P.; Teegerstrom, T.; Summers, H.M.; Sproul, E. N.D.** Enterprise Budgets: Guar, Flood Irrigation, Southern New Mexico Production. *New Mexico State University Extension Publication*. [In Review]
 15. **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.
 16. **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://bmcpantbiol.biomedcentral.com/articles/10.1186/s12870-019-2106-2>
 17. **Rodriguez-Uribe, L.; Von Cruz, V.M.; Willette, S.; Gil, S.; Khadijeb, M.; Dierig, D.A.; Holguin, F.O. N.D.** Untargeted metabolome profiling of guayule (*Parthenium argentatum* A.Gray) to identify metabolic biomarkers for cold-acclimated and freezing temperature tolerance. *Industrial Crops and Products*. [In Review]
 18. **Sproul, E.; Summers, H.M.; Seavert, C.; Robbs, J.; Khanal, S.; Mealing, V.; Landis, A.E.; Fan, N.; Sun, O.; Quinn, J.C. N.D.** Integrated Techno-Economic and Environmental Analysis of Guayule Rubber Production. *Journal of Cleaner Production* [In Press]. Accepted June 2020.
 19. **Singh, J. N.D.** Guar Growth and Development Under Pre-Irrigation and In-Season Irrigation Management in the Southern High Plains. *Journal of Industrial Crops and Products*. Accepted June 2020.
 20. **Singh, J.; Guzman, I.; Begna, S.; Trostle, C.; Angadi, S.V. 2021.** Germination and early growth response of guar cultivars to low temperatures. *Industrial Crops and Products*. Volume 159, 2021, 113082, ISSN 0926-6690. DOI:10.1016/j.indcrop.2020.113082
 21. **Sun, O.; Fan, N. 2020.** A Review on Optimization Methods for Biomass Supply Chain: Models and Algorithms, Sustainable Issues, Challenges and Opportunities. *Process Integration and Optimization for Sustainability*, published online first, 3/2020. DOI:10.1007/s41660-020-00108-9
 22. **Summers, H.M.; Sproul, E.; Seavert, C.; Angadi, S.; Robbs, J.; Khanal, S.; Gutierrez, P.; Teegerstrom, T.; Zuniga Vasquez, D.A.; Fan, N.; Quinn, J.C. N.D.** Economic and Environmental Analyses of Incorporating Guar into the American Southwest Agricultural Systems. [In Review]
 23. **Teegerstrom, T.; Seavert, C.; Gutierrez, P.; Summers, H.A.; Sproul, E. N.D.** Guayule Enterprise Budget: Guayule, Flood Irrigated, Southern Arizona. *University of Arizona, Extension Publication*. [In Review]

24. **Wang, S.; Lynch, A.; VonCruz, M.; Heinitz, C.; Dierig, D. N.D.** Temperature Requirements for Guayule Seed Germination. *Industrial Crops and Products* [In Press] Accepted September 2020.
25. **Zuniga-Vasquez, D.A.; Sun, O.; Fan, N.; Sproul, E.; Summers, H.M.; Quinn, J.C.; Khanal, S.; Gutierrez, P.; Mealing, V.A.; Landis, A.E.; Seavert, C.; Teegerstrom, T.; Evancho, B. 2021.** Integrating Environmental and Social Impacts into Optimal Design of Guayule and Guar Supply Chains. *Computers and Chemical Engineering*. DOI: 10.1016/j.compchemeng.2021.107223.
26. **Zuniga-Vasquez, D.A.; Fan, N.; Teegerstrom, T.; Seavert, C.; Summers, H.M.; Sproul, E.; Quinn, J.C. N.D.** Optimal Production Planning and Machinery Scheduling for Semi-Arid Farms. *Computers and Electronics in Agriculture*. [Accepted 12/2020]

Capstone Projects, Theses, and Dissertations

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

Conference Papers

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

- stress: A comparative RNA-Seq study*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 35.
7. **El-Shikha, D.E.M.*; Waller, P.M.; Hunsaker, D.J.; Dierig, D.A.; Wang, G.S.; Cruz, V.M.V.; Thorp, K.R.; Bronson, K.F.; Katterman, M.E. 2019.** *Growth and yield of direct-seeded guayule under SDI and furrow irrigation*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 30.
 8. **Khanal, S.; Robbs, J.; Acharya, R.; Gutierrez, P. 2019.** *Import demand and potential for domestic production of guar*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 43.
 9. **Maqsood, H.; Waller, P.; El-Shikha, D.E.M.; Hunsaker, D.; Katterman, M.E.; Dierig, D.A.; Wang, G.S.; Ogden, K. 2019.** *Assessment of irrigation requirement for guayule using WINDS model*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 32.
 10. **Maqsood, H.; Angadi, S.; El-Shikha, D.E.M.; Waller, P.; Singh, J.; Hunsaker, D.; Barau, B. 2019.** *Evaluating crop water status for guar using WINDS model*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 42.
 11. **McCloskey, W.; Wang, G.S. 2019.** *Guayule (Parthenium argentatum A. Gray) seedling tolerance to topically applied carfentrazine-ethyl herbicide*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 34.
 12. **Placido, D.F.; Dong, N.; Pham, T.; Huynh, T.; Amer, B.; Baidoo, E.; McMahan, C. 2019.** *Down-regulation of squalene synthase in guayule (Parthenium argentatum)*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 37.
 13. **Seavert, C.; Teegerstrom, T.*; Gutierrez, P.; Khanal, S. 2019.** *Whole farm analysis tool for evaluating the adoption of guayule and guar into southwest producers' current operation*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.).Tucson, Arizona. 8-11 September. p. 40. Best Oral Presentation Award for the Rubber and Resin Division.
 14. **Wang, G.S.; Dierig, D.A.; Ray, D.T. 2019.** *Guayule response to plant population*. In: 31st Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 38.

Scholarly Presentations

1. **Angadi, S.V. 2018.** *Sustainable Bio-economy for Arid Regions: Growing Guar*. Extension Field Day. Clovis, New Mexico. 9 August.
2. **Angadi, S.V.; Singh, J.; Guzman, I.; Begna, S. 2020.** *Germination temperature for expanding guar acres to cooler regions*. American Society of Agronomy, Crop Science

- Society of America, and Soil Science Society of America (ASA-CSSA-SSSA) Joint International Annual Meeting. Virtual. 8-11 November.
3. **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.
 4. **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.
 5. **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.
 6. **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.
 7. **Angadi, S.V.; Singh, J.*; Begna, S.H. 2020.** *Crop growth stage-based deficit irrigation management in guar crop*. Annual Report, Agricultural Science Center at Clovis, New Mexico. 29 February.
 8. **Angadi, S.V.; Singh, J.*; Begna, S.H. 2020.** [Germination temperature for expanding guar across to cooler regions. ASA, CSSA and SSSA International Annual Meetings \(Virtual\). 8-11 November.](#)
 9. **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.
 10. **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]
 11. **Brewer, C.E. 2018.** *Pairing biomass residues with conversion technologies*. Advanced Bioeconomy Leadership Conference, Washington, D.C. 28 February.
 12. **Brewer, C.E. 2018.** *Polymerization and guar gum bubbles*. Outreach event activity. New Mexico 4-H State Conference. 11 July.
 13. **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.
 14. **Brown, K.S. 2020.** *Soil chemistry ... and other topics*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 25 March.
 15. **Brown, K.S. 2020.** [Pathogens and Guayule \(*Parthenium argentatum*\): Literature Review](#). SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. [virtual] 18 November.
 16. **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]
 17. **Brown, K.S.*; Neilson, J.W. 2018.** *Microbial contributions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. April.
 18. **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]
19. **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]
 20. **Brown, K.S.*; Neilson, J.W.; Waller, P.M.; Ray, D.T.; Wang, S.; Dierig, D.; El-Shikha, D.E.M.; Maier, R.M. 2020.** *Fungal pathogens and guayule (*Parthenium argentatum*): Optimizing crop production in an arid environment*. University of Arizona ENViSion Virtual Earth Week Conference, Tucson, Arizona. April.
 21. **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.
 22. **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.
 23. **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.
 24. **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.
 25. **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.
 26. **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.
 27. **Creegan, E.; Grover, K.*; DuBois, D.; Khan, N. 2020.** *Global climate change mitigation and resiliency: Agriculture Curriculum Collaborations*. North America Colleges and Teachers of Agriculture Virtual Conference, Online. 15-18 June.
 28. **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]
 29. **Dehghanizadeh, M.*; Brewer, C. 2020.** *Guayule resin: Advanced extraction techniques and promising commercial applications*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
 30. **Dehghanizadeh, M.; Brewer, C. 2020.** *A study on chemistry and fractionation of guayule resin as a source of secondary metabolites and energy*. AIChE Annual Meeting (virtual). 15 November.

31. **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.
32. **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]
33. **El-Shikha, D.E.M. 2018.** *Update – Guayule irrigation experiments at Maricopa Agricultural Center.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 12 September.
34. **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]
35. **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]
36. **Evancho, B.*; Teetor, V.H.; Willmon, J.; Bennett, M.C.; Montes, M.; Schmalzel, C.; Ray, D.T. 2018.** *Root structure differentiation between common guayule planting methods.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
37. **Evancho, B. 2018.** *Guayule Fuels the Future.* IES – Energy Talks Seminar, Sky Bar, Tucson, Arizona. 9 October.
38. **Evancho, B. 2019.** *Guayule: How Close Are We?* Marana Winter Field Crops Clinic. Marana, Arizona. 10 January.
39. **Evancho, B. 2019.** *Guayule: How Close Are We?* Casa Grande Winter Field Crops Clinic. Casa Grande, Arizona. 15 January.
40. **Evancho, B. 2019.** *Comparing direct-seeded and transplanted guayule roots.* SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 13 November.
41. **Evancho, B. 2020.** *Growth response of guayule to a gradient of nitrogen fertilizer.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 29 April.
42. **Evancho, B.*; Lewis, M.; Schmalzel, C.; Teetor, V.; Ray, D. 2020.** *Agronomic investigations to improve guayule production.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
43. **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]
44. **Fan, N. 2018.** *Review on Optimization Methods for Biomass Supply Chain.* SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
45. **Fan, N.; Sun, O. 2019.** *GIS-based, two-stage stochastic facility location problem considering planting plan uncertainty.* American Institute of Chemical Engineers (AIChE) Annual Meeting, Orlando, Florida. 11 November.
46. **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.
47. **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]
 48. **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.
 49. **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.
 50. **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.
 51. **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]
 52. **Garcia, A.*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2020.** *Growth and performance of guar genotypes under various irrigation regimes and addition of biogenic silica in Southwest New Mexico*. SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
 53. **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]
 54. **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.
 55. **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.
 56. **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]
 57. **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.
 58. **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.

59. **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]
60. **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]
61. **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.
62. **Grover, K. 2018.** *Sustainable agriculture and guar production in New Mexico.* New Mexico State 4-H Conference, Las Cruces, New Mexico. 10 July.
63. **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.
64. **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.
65. **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.
66. **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.
67. **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.
68. **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.
69. **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]
70. **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.
71. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico.* New Mexico Master Gardener's Meeting. Las Cruces, New Mexico. 8 May.
72. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico.* New Mexico Sustainable Agriculture Field Day. Las Cruces, New Mexico. 26 June.
73. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico.* SBAR Train-the-Trainer Workshop. Las Cruces, New Mexico. 2 July.
74. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico.* SBAR Train-the-Trainer Workshop, Las Cruces, New Mexico. 2 July.
75. **Grover, K. 2019.** *Guar research and extension program in New Mexico.* Departmental External Review, Las Cruces, New Mexico. 10 October.

76. **Grover, K. 2020.** *Guar as an alternative crop in southwest USA*. 18th International Congress of Soil Science, Sindh Agriculture University, Tandojam, Pakistan. 11-13 February. [invited speaker]
77. **Grover, K. 2020.** *Guar in changing climate*. Climate Change Strategies for a Changing World, New Mexico State University, Las Cruces, New Mexico. 3 March. [invited speaker]
78. **Grover, K. 2020.** *Guar as a potential alternative crop*. Introductory Plant Sciences course (AGRO/HORT 100G), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
79. **Grover, K. 2020.** *Evaluating performance of guar genotypes*. Special Problems/Special Topics Seminar (AGRO 449/AGRO 500), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
80. **Grover, K. 2020.** *Teaching principles of plant growth and development*. Teaching Assistant Training and Supervised University Teaching Experience (AGRO 697), New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
81. **Grover, K. 2020.** *Evaluating guar for its adaptability in New Mexico*. Research and Education Training Workshop. New Mexico State University, Las Cruces, New Mexico (Online). May. [invited speaker]
82. **Grover, K. 2020.** *Growth and Performance of Guar Under Various Moisture Stress Regimes*. Proceedings of the 2020 Annual Meeting of the American Society of Agronomy, Crop Science Society of America and the Soil Science Society of America. [Virtual Meeting] 9-11 November.
83. **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.
84. **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.
85. **Grover, K.*; Garcia, A.; Schutte, B.J.; Stringam, B.; Darapuneni, M.K.; VanLeeuwen, D; Flynn, R.P. 2020.** *Growth and performance of guar under various moisture stress regimes*. Western Crop Science Society of America Annual Virtual Conference, Online. 7 July.
86. **Grover, K.*; Stovall, S. 2020.** *Integrating experiential learning in a crop production course*. North America Colleges and Teachers of Agriculture Virtual Conference, Online. 15-18 June.
87. **Grover, K.*; Torres, S.; Cazarez, K. 2020.** *Response of Guar to Various Seeding Rates*. Proceedings of the 2020 Annual Meeting of the American Society of Agronomy, Crop Science Society of America and the Soil Science Society of America. [Virtual Meeting] 9-11 November.
88. **Gutierrez, P.; Khanal, S.; Seavert, C.; Teegerstrom, T. 2020.** *Economic impacts of producing alternative crop: guar, guayule and industrial hemp in New Mexico*. Alternative Crops Conference. Portales, New Mexico. 10 March.
89. **Hoare, D.M. 2018.** *Irrigation Sensors and the WINDS Model*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 26 September.
90. **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]
91. **Huynh, T.*; Resendiz, M.; McMahan, C.; Dong, N. 2019.** *The Content and State of the In-Vitro Guayule Inventory in Tissue Culture and Opportunities to Improve our Methods.* Seminar Presentation and Discussion, USDA-ARS WRRC, Albany, California. 18 November.
 92. **Idowu, O.J. 2018.** *Introduction to the SBAR Project.* Las Cruces, New Mexico. 6 Feb.
 93. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Update.* Extension Field Day, Clovis, New Mexico. 9 August.
 94. **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.
 95. **Idowu, O.J. 2020.** *Potential of guar for Eastern New Mexico (Sustainable Bioeconomy for Arid Regions Project).* Tucumcari Agricultural Science Center Virtual Field Day, Tucumcari, New Mexico. 6 August.
 96. **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.
 97. **Katterman, M. 2020.** *Guayule sensor and irrigation modeling + SBAR Education update.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 18 March.
 98. **Khanal, S. 2020.** *Industrial uses of guar as a rural economic development strategy in the Southwest.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
 99. **Khanal, S.*; Gutierrez, P. 2020.** *The economic impact of the alternative crops: Guar and guayule production in the Southwest.* Agricultural and Applied Economics Association (AAEA) 2020 Virtual Meeting. 10-11 August. [poster]
 100. **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.
 101. **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]
 102. **Khanal, S.; Gutierrez, P.; Seavert, C.; Teegerstrom, T. 2020.** *The economic impacts of producing guar using the input-output model.* New Mexico Alternative Crops Conference, Portales, New Mexico. 10 March. [poster]
 103. **Khanal, S.; Gutierrez, P.; Seavert, C.; Teegerstrom, T. 2020.** *Guar research manuscript update.* SBAR System Performance and Sustainability Seminar. Colorado State University, Fort Collins, Colorado. 15 April.
 104. **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]
 105. **Ledesma, J.*; Ossanna, L.; Pacido, D.; El-Shikha, D.E.; Dong, C.; Ponciano, G.; McMahan, C.; Neilson, J.W.; Maier, R.M. 2020.** *Associations between soil bioavailable phosphorus and guayule plant growth and rubber production.* 31st Annual

Undergraduate Biology Research Program Conference, University of Arizona, Tucson, Arizona. 25 January.

106. **Ledesma, J.*; Ossanna, L.; Pacido, D.; El-Shikha, D.E.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M.; Neilson, J.W. 2020.** *Associations between soil bioavailable phosphorus, phosphorus solubilizing microorganisms, and guayule growth stage and rubber production.* University of Arizona ENViSion Virtual Earth Week Conference, Tucson, Arizona. April. [poster]
107. **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.
108. **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]
109. **Lewis, M. 2019.** *Salt stress tolerance in guayule.* SBAR UA Research Team Seminar, University of Arizona, Tucson, Arizona. 23 October.
110. **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]
111. **Lohr, P. 2020.** *AquaCrop modeling of guayule.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 5 February.
112. **Lohr, P.*; Ogden, K. 2020.** *Modeling guayule: Adapting AquaCrop model for a perennial crop.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
113. **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.
114. **Lopez, E.*; Fox, S.; Brewer, C.E. 2018.** *GK-12 Lesson Documentation Spreadsheet.* American Institute of Chemical Engineers Annual Meeting, Pittsburg, Pennsylvania. 29 October.
115. **Madasu, C.*; Gunatilaka, L. 2020.** *Semi-synthesis and cytotoxicity evaluation of some pyrimidine analogues of argentatins A-C isolated from guayule (Parthenium argentatum) resin.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
116. **Maqsood, H. 2018.** *Guar Crop Coefficient Development for New Mexico Environments.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 7 November.
117. **Maqsood, H. 2020.** *Model parameterization for guar irrigation schedule and biomass estimation using remote sensing.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 1 April.
118. **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]
119. **Maqsood, H.*; Waller, P.; El-Shikha, D.; Katterman, M.; Hoare, D.S.L.; Angadi, S.; Dierig, D. 2020.** *Analysis of soil moisture and crop vegetation for guayule and guar using irrigation models and remote sensing techniques.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.

120. **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]
121. **McCloskey, W. 2018.** *Weed Trial Results for Guayule.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 14 November.
122. **McCloskey, W. 2019.** *Guayule Weed Control Research.* The 9th Annual Central Arizona Farmer Field Day. Maricopa Agricultural Center (MAC), Maricopa, Arizona. 8 October.
123. **McCloskey, W. 2020.** *2019 Herbicide Progress Report: Aim herbicide experiments and preemergence herbicide experiment failures.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 29 January.
124. **McMahan, C. 2018.** *Flowering Reduction in Guayule.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 19 September.
125. **McMahan, C. 2019.** *USDA-ARS Rubber Lab Update.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 27 March.
126. **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]
127. **McMahan, C.*; Placido, D.; Resendiz, M.; Ponciano, G. 2020.** Flowering downregulation in guayule. Update to SBAR Advisory Board. Online presentation. 12 February.
128. **McMahan, C.*; Placido, D.; Resendiz, M.; Ponciano, G.; Dong, C. 2020.** Flowering downregulation in (Parthenium argentatum). SBAR UA Research Team Seminar Series, Tucson, Arizona. 9 December.
129. **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.
130. **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.
131. **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]
132. **Mealing, V. 2019.** *Field Data Collection and Integration.* SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 13 November.
133. **Mealing, V. 2020.** *Field data collection update.* SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 19 February.
134. **Mealing, V. 2020.** *Field data integration update.* SBAR System Performance and Sustainability Seminar, Colorado State University, Golden, Colorado. 25 June.
135. **Mealing, V. 2020.** *A framework for assessing the social sustainability of guar agriculture.* Congress on Sustainability and Engineering (ICOSSE) (virtual). Golden, Colorado. 3 August.
136. **Mealing, V. 2020.** *Towards a holistic sustainability assessment of guar and guayule.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.

137. **Mealing, V. 2020.** *Agricultural LCA of guar: Comparing N&P fertilizer scenarios from field trials.* American Center for Life Cycle Assessment Conference (ACLCA) (virtual). Golden, Colorado. 22 September.
138. **Mealing, V. 2020.** *Sustainability assessment of guar and guayule cultivation: Utilizing unique field trial data.* USDA Rubber Lab Meeting (virtual). Golden, Colorado. 10 December.
139. **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.
140. **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.
141. **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]
142. **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]
143. **Mealing, V.S.*; Landis, A.E. 2019.** *SBAR Sustainability.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
144. **Mealing, V.S. 2020.** *Towards a holistic sustainability assessment of guar and guayule.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
145. **Mendoza, P.*; Sproul, E.; Quinn, J. 2020.** *High-value co-products from guayule resin and bagasse.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
146. **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]
147. **Morris, N.A. 2020.** *SBAR 4-H opportunities and future directions.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 19 February.
148. **Morris, N.A. 2020.** *Arizona 4-H SBAR Capacity Building: Outcomes, progress, and plans.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
149. **Morris, N.A. 2020.** *Realizing the Aim of Education for Sustainability Through 4-H.* National Association of Extension 4-H Youth Development Professionals (NAE4-HYDP) Annual Meeting. Boise, Idaho. October.
150. **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]
151. **Neilson, J.W.; Ossanna, L. 2020.** *Associations between the guayule rhizosphere microbiome and plant growth architecture, and rubber/resin production.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 4 March.

152. **Nieblas, A. I. 2020.** *Development of educational materials with a focus on arid regions.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
153. **Niu, D., 2018.** *Partial cloning of APETALA1 (AP1) gene from guayule.* cDNA Lab Seminar, USDA-ARS Western Regional Research Laboratory. 28 March.
154. **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]
155. **Ogden, K. 2017.** *Sustainable Bioeconomy for Arid Regions.* Biomass Research and Development Technical Advisory Board Meeting. 15 November. [invited speaker]
156. **Ogden, K. 2018.** *Sustainable Bio-economy for Arid Regions.* Southwest Indian Agricultural Association Annual Meeting. Laughlin, Nevada. 16-18 January.
157. **Ogden, K. 2018.** *Potential of the Bioproducts and Biofuels Economy.* AIChE Annual Meeting, Pittsburg, Pennsylvania. October [invited speaker]
158. **Ogden, K. 2020.** *Sustainable Bioeconomy for Arid Regions.* Grain Processing Lecture Series, Michigan Technological University, Houghton, Michigan. 17 January [invited speaker]
159. **Ogden, K. 2020.** *SBAR Project Update.* Southwest Indian Agriculture Association (SWIAA) 32nd Annual Conference, Laughlin, Nevada. 20-23 January [invited speaker]
160. **Ogden, K. 2020.** *Sustainable Bioeconomy for Arid Regions.* University of Utah, Salt Lake, Utah. 2 March. [invited distinguished lecturer]
161. **Ogden, K.*, White, R., Brewer, C.E. 2018.** *Public Private Partnerships.* ABLC Conference. Washington, D.C. 27-28 February.
162. **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]
163. **Ossanna, L.*; Brown, K.; Chen, Y.; Maier, R.; Neilson, J.; Placido, D.; Dong, C.; Ponciano, G.; McMahan, C.; El-Shikha, D.; Waller, P.; Wang, S.; Dierig, D. 2020.** *The significance of the soil microbiome to guayule production.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
164. **Phakdon, T. 2020.** *Plant adaptation in the Sonoran Desert: A lesson for middle school students.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
165. **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]
166. **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.
167. **Pruitt, D.*; Idowu, O.J.; Angadi, S.; Darapuneni, M.; Sanogo, S. 2020.** *Guar growth and yield as affected by nitrogen and phosphorus inputs.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
168. **Pruitt, D.J.*; Idowu, O.J.; Angadi, S.; Darapuneni, M.K.; Sanogo, S. 2020.** *Guar growth and yield as affected by nitrogen and phosphorus inputs.* ASA-CSSA-SSSA Annual Meeting (virtual), 11 November.

169. **Quinn, J.C.*; Summers, H.M.; Sproul, E.; Seavert, C.; Teegerstrom, T.; Gutierrez, P.; Robbs, J.; Mealing V.; Landis, A.E.; Fan, N.; Sun, O.; Zuniga-Vasquez, D. 2020.** *Integrated economic and environmental analysis of emerging industrial crops in arid regions of the Southwest United States.* International Symposium on Sustainable Systems and Technologies (virtual). 4 August.
170. **Quinn, J.C.*; Sproul, E.; Summers, H.M.; Seavert, C.; Gutierrez, P.; Teegerstrom, T.; Zuniga-Vazquez D.; Robbs, J.; Khanal, S.; Fan, N.; Sun, O.; Moreno, P.M. 2020.** *Integrated economic and environmental analysis of emerging industrial crops in arid regions of the Southwest United States.* American Chemical Society Fall 2020 Meeting and Expo (virtual). 17-20 August.
171. **Resendiz, M. 2020.** *Flowering downregulation of Parthenium argentatum.* USDA-ARS Lab Meeting, Albany, California. 14 May.
172. **Resendiz, M. 2020.** *Downregulation of floral identity genes in Parthenium argentatum.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
173. **Rock, C.*; Brassill, N. 2018.** *Importance of Cooperative Extension in University Research.* University of Arizona, Tucson, Arizona. 14 March.
174. **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]
175. **Rogstad, A. 2019.** *SBAR Overview.* Association for the Advancement of Industrial Crops 31st Annual Meeting. Tucson, Arizona. 8 September. [invited speaker]
176. **Rogstad, A. 2021.** *SBAR Overview. Arizona Institutes for Resilience: Solutions for the Environment and Society Seminar. Tucson, Arizona. 10 February [invited speaker]*
177. **Rodriguez-Uribe, L.. 2020.** *Identification of metabolic biomarkers for cold-acclimation and freezing temperature tolerance in guayule (Parthenium argentatum, A. Gray).* Fall 2020 Friday Kick-off of the PES Graduate Research Seminar (virtual), Las Cruces, New Mexico. 28 August.
178. **Rodriguez-Uribe, L.*; Gutierrez, P. 2019.** *Implementing the Science of SBAR with Youth.* SBAR UA Research Team Seminar, University of Arizona, Tucson. 25 September.
179. **Rodriguez-Uribe, L.*; Gutierrez, P.; Rogstad, A.; Fields, J. 2020.** *Achievements of the SBAR Extension and Outreach Team in New Mexico.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
180. **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]
181. **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.
182. **Sehar, U.*; Rodriguez-Uribe, L.; Von Cruz, M.; Willette, S.; Mozaffari, K.; Dierig, D.; Holguin, F.O. 2020.** *Untargeted metabolome profiles on the guayule germplasms AZ-2 and W6-429 to identify metabolic biomarkers for cold-acclimation and freezing temperature tolerance.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.

183. **Singh, J. 2020.** *Guar growth and development under pre-season and in-season irrigation management in the southern High Plains.* Master of Science Thesis. New Mexico State University, Las Cruces, New Mexico. 3 April.
184. **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]
185. **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.
186. **Singh, J.*; Angadi, S.V.; Begna, S.H. 2020.** *Identify guar germplasm suitable for cooler northern latitudes of the Southern High Plains.* *In:* Agricultural Science Center 2020 Annual Report. New Mexico State University, Clovis, New Mexico.
187. **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]
188. **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.
189. **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.
190. **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.
191. **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.
192. **Singh, J.*; Angadi, S.V.; Begna, S.H.; VanLeeuwen, D.; Idowu, O.J.; Guzman, I. 2020.** *Sustaining Irrigation Water of the Southern High Plains Using Guar.* New Mexico Alternative Crops Conference, Portales, New Mexico. 10 March. [poster]
193. **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]
194. **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.
195. **Smith, A. 2020.** *Valorization of guayule resin.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 22 April.
196. **Smith, A.*; Ogden, K. 2020.** *Vacuum distillation of guayule resin.* SBAR Annual Retreat (virtual). University of Arizona, Tucson, Arizona. 27-29 July.

197. **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]
198. **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.
199. **Sproul, E. 2020.** *Integrated Economic & Environmental Analysis of Guayule and Guar Production.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 22 January.
200. **Sproul, E. 2020.** *Techno-economic analysis and life cycle assessment of guayule.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
201. **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.
202. **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]
203. **Sun, O. 2018.** *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty.* INFORMS Annual Meeting, Phoenix, Arizona. 5 November.
204. **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.
205. **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.
206. **Sun, O. 2019.** *Biomass Supply Chain Configuration and Management.* SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 10 April.
207. **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.
208. **Sun, O.*; Fan, N. 2018.** *Harvest scheduling.* SBAR Logistics Team Group Meeting. (webinar) New Mexico State University. Las Cruces, New Mexico. 5 February.
209. **Sun, O.*; Fan, N. 2018.** *Optimization of feedstock logistics.* SBAR UA Research Seminar. University of Arizona. Tucson, Arizona. 14 February.
210. **Sun, O.*; Fan, N. 2018.** *Optimally locating biorefineries.* SBAR Sustainability Working Group Seminar. (webinar) Colorado State University. Lakewood, Colorado. 8 March.
211. **Summers, H. 2020.** *Techno-economic analysis and life cycle assessment of guar.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
212. **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.

213. **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.
214. **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.
215. **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.
216. **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.
217. **Teegerstrom, T; Seavert, C. 2020.** *Whole farm analysis for evaluating the adoption of guayule and guar into Southwest producers' current operations.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 12 February.
218. **Teegerstrom, T.*; Seavert, C.; Khanal, S.; Gutierrez, P. 2020.** *Whole farm analysis and enterprise budget tools for evaluating the adoption of guayule and guar into Southwest producers' current operation.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
219. **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]
220. **Usrey, J. 2020.** *Development of middle school STEM classroom lesson plans for after school program activities.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
221. **Usrey, J.*; Rosalez, R.; Brewer, C.E. 2020.** *Development of middle school STEM classroom lesson plans and afterschool program activities to support USDA-sponsored project on alternative crop bioeconomy.* American Institute of Chemical Engineers (AIChE) Annual Meeting. (Virtual) 15 November.
222. **Waller, P. 2018.** *WINDS Model: A status report and connection to SBAR research.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 10 October.
223. **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]
224. **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.
225. **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]
226. **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]

- 227. 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]
- 228. Zuniga-Vasquez, D. 2019.** *Stochastic scenarios for guayule production.* SBAR System Performance and Sustainability Seminar, Colorado State University, Fort Collins, Colorado. 8 October.
- 229. 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.
- 230. Zuniga-Vasquez, D. 2020.** *Optimization for guayule and guar logistics and transportation.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 8 April.
- 231. Zuniga-Vasquez, D.*; Fan, N. 2020.** *Optimization for guayule and guar logistics and transportation.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 19 February.
- 232. Zuniga-Vasquez, D.*; Fan, N. 2020.** *Integrating environmental and social impacts into optimal design of guayule and guar supply chains.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
- 233. Zuniga-Vasquez, D.*; Fan, N. 2020.** *Smart farm production and scheduling design for guayule and guar.* SBAR Annual Retreat (virtual), University of Arizona, Tucson, Arizona. 27-29 July.
- 234. Zuniga-Vasquez, D.*; Fan, N. 2020.** *Smart farm production and scheduling design for guayule and guar.* SBAR Sustainability Team Meeting, University of Arizona, Tucson, Arizona. 30 September.
- 235. Zuniga-Vasquez, D.*; Fan, N. 2020.** *Smart farm production and scheduling design for guayule and guar.* SBAR Research Team Meeting, University of Arizona, Tucson, Arizona. 30 September.
- 236. Zuniga-Vasquez, D.*; Sun, O.; Fan, N. 2020.** *Optimization for guayule and guar logistics and transportation integrating environmental and social impacts on the supply chain.* New Mexico Alternative Crop Conference, Portales, New Mexico. 10 March. [poster]

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

Audience Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
Gender			
Males	1,935	129	2,064
Females	912	87	999
Race/Ethnicity			
Hispanic	470	6	476
Asian	242	2	244
Native American	353	3	356
African American	73	2	75
Anglo/White	1,709	23	1,732
Unknown	0	180	180

Audience Cumulative Total (when captured): 3,063 ppl

WEBSITE(S) OR INTERNET SITE(S)

SBAR Project Website

1. [.https://sbar.arizona.edu](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.
3. **Sep 2020.** Patent # 506319647 (REEL/FRAME: 054154/0921) UA21-25 – Adhesives.
4. **Sep 2020.** Patent # 506319660 (REEL/FRAME: 054154/0977) UA21-26 – Particle Board.

OTHER PRODUCTS GENERATED

Brochures, Factsheets, and Flyers

1. **Duncan, C.M. 2018.** SBAR USDA-NIFA graduate student fellowship: UA Students. One page promotional flyer. February and March.
2. **Duncan, C.M. 2018.** SBAR USDA-NIFA graduate student fellowship: NMSU Students. One page promotional flyer. February and March.
3. **Duncan, C.M. 2018.** SBAR call for middle and high school science teachers. One page promotional flyer. February and March.
4. **Duncan, C.M. 2018.** SBAR 4-H summer camp: Biofuels powering your world. One page promotional flyer. March.
5. **Duncan, C.M. 2019.** SBAR Call for Middle & High School Science Teachers. One page promotional flyer. March.
6. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate student fellowship: UA Students. One page promotional flyer. March.
7. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate student fellowship: NMSU Students. One page promotional flyer. March.
8. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate science education fellowship. One page general recruiting flyer. April.

9. **Evancho, B. 2019.** Guayule Information & Feedback Session. One page invitation to attend field day and tour. May.
10. **Grover, K. 2018.** Guar – A potential alternative crop in New Mexico. Two page informational handout. January.
11. **Kiela, C. 2018.** Guayule. SBAR Project two-page fact sheet. March.
12. **Kiela, C. 2018.** Guar. SBAR Project two-page fact sheet. April.
13. **Kiela, C. 2018.** History of Guayule. SBAR Project two-page fact sheet. April.
14. **Rogstad, A. 2017.** SBAR – Sustainable Bioeconomy for Arid Regions. One-page informational and promotional card. November.

Press Releases and News Articles

1. 26 Sep 2017. “As NIFA awards \$21.1M to grow the bioeconomy, CABLE debuts to bridge students and industry.” BiofuelsDigest. <http://www.biofuelsdigest.com/bdigest/2017/09/26/as-nifa-awards-21-1m-to-grow-the-bioeconomy-cable-debuts-to-bridge-students-and-industry/>
2. 16 Oct 2017. “UA to Head New Center Focusing on Biofuels and Bioproducts.” UA News. <https://uanews.arizona.edu/story/ua-head-new-center-focusing-biofuels-and-bioproducts>
3. 4 Nov 2017. “Biofuels, bioproducts, and an Arizona bioeconomy?” Arizona Daily Wildcat. <http://www.wildcat.arizona.edu/article/2017/11/science-biofuels-and-bioproducts>
4. 29 Nov 2017. “NMSU to host state sustainable agriculture conference in Los Lunas.” News Bulletin. http://www.news-bulletin.com/news/nmsu-to-host-state-sustainable-agriculture-conference-in-los-lunas/article_a45281f6-d540-11e7-9530-27dc93258a79.html
5. 16 Jan 2018. “Dr. Quinn’s Sustainability Expertise Recruited for Multi-Million Dollar DOE and USDA Grants.” Colorado State University, Mechanical Engineering Featured Projects. <http://www.engr.colostate.edu/me/2018/01/16/dr-quinns-sustainability-expertise-recruited-for-multi-million-dollar-doe-and-usda-grants/>
6. 21 Feb 2018. “NMSU collaborating in Sustainable Bio-economy for Arid Regions project.” New Mexico State University News Center. <http://newscenter.nmsu.edu/Articles/view/12961/nmsu-collaborating-in-sustainable-bio-economy-for-arid-regions-project>
7. 27 Feb 2018. “Bridgestone receives guayule research grant from USDA.” The Smithers Report - A daily and weekly tire industry news source. (4,500 daily subscribers) <https://www.smithersrapra.com/publications/the-smithers-report>
8. 27 Feb 2018. “Bridgestone and research partners earn \$15 Million grant for guayule work.” MTD (Modern Tire Dealer). UMV: 62,085. <http://www.moderntiredealer.com/news/728673/bridgestone-and-research-partners-earn-15-million-grant-for-guayule-work>

Tabling Events and Workshops – Marketing and Outreach

1. 14 July 2017. New Mexico Cotton Ginners Conference. New Mexico.
2. 17 Aug 2017. SBAR Project Kick-off Meeting. Tucson, Arizona.
3. 28 Oct 2017. Rocky Mountain Zone Summit (sustainability focus). Denver, Colorado.
4. 05 Dec 2017. Valencia County (New Mexico) Forage Conference. New Mexico.
5. 13 Dec 2017. New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico.
6. 15-17 Feb 2018. SBAR Display Table. New Mexico Organic Farming Conference. Albuquerque, New Mexico.
7. 24 Feb 2018. Farm Science Day. USDA-ARS, Arid-Land Agricultural Resource Center. Maricopa, Arizona.
8. 24 Feb 2018. 2018 Engineering Fair – Recycled papermaking and guar gum bubbles activity. Las Cruces Museum of Science and Nature. Las Cruces, New Mexico.
9. 15 Mar 2018. Zia Middle School Project – Lead the Way NMSU College of Engineering Day. Recycled papermaking and guar gum bubbles activity. Las Cruces, New Mexico.
10. 22-24 Feb 2018. Southwest Ag Summit. Yuma, Arizona.
11. 19 Mar 2018. Roosevelt Irrigation District Board Meeting. Buckeye, Arizona.
12. 28 Mar 2018. Alfalfa and Forage Workshop. Maricopa, Arizona.
13. 11 Jul 2018. New Mexico 4-H State Conference – Polymerization and guar gum bubbles activity. Albuquerque, New Mexico.
14. 9 Aug 2018. Extension Field Day, New Mexico State University Agricultural Science Center, Clovis, New Mexico.
15. 23 Aug 2018. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico.
16. 12 Dec 2018. New Mexico Sustainable Agriculture Conference, Las Cruces, New Mexico.
17. 10 Jan 2019. Marana Winter Field Crop Clinic. University of Arizona Cooperative Extension, Marana, Arizona.
18. 15 Jan 2019. Casa Grande Winter Field Crop Clinic. University of Arizona Cooperative Extension, Casa Grande, Arizona.
19. 23 Jan 2019. New Mexico Cotton Growers Association Conference, Ruidoso, New Mexico.
20. 13 Feb 2019. Desert Hills S.T.E.A.M. Night. (Science, Technology, Engineering, Art, and Math) Desert Hills Elementary School, Las Cruces, New Mexico.
21. 15-16 Apr 2019. New Mexico Organic Farming Conference, Albuquerque, New Mexico.
22. 11 Apr 2019. Spring Extension Field Day, New Mexico State University Agricultural Science Center, Clovis, New Mexico.
23. 15 May 2019. Annual Agricultural Research Congressional Exhibition and Reception. Rayburn House, Washington, D.C.
24. 30 May 2019. Market Discussion and Field Day. Bridgestone Guayule Research Farm, Eloy, Arizona.
25. 26 Jun 2019. Extension Field Day. Fabian Garcia Research Center, Las Cruces, New Mexico.
26. 2 Jul 2019. SBAR Train the Trainers Workshop. Las Cruces, New Mexico.
27. 8 Aug 2019. Annual Agricultural Field Day. Agricultural Science Center, Clovis, New Mexico.

28. 8 Aug 2019. Agricultural Science and Field Day. Agricultural Science Center, Tucumcari, New Mexico.
29. 15 Aug 2019. Annual Agricultural Field Day. Agricultural Science Center, Los Lunas, New Mexico.
30. 21 Aug 2019. USAID Cochran Fellows Visit from Mali, Clovis, New Mexico.
31. 12 Oct 2019. Cooperative Extension Day. Maricopa Agricultural Center (MAC), Maricopa, Arizona.
32. 14 Jan 2020. Winter Field Crops Meeting, Pima County, Arizona.
33. 15 Jan 2020. Winter Field Crops Meeting, Pinal County, Arizona.
34. 29 Jan 2020. New Mexico Cotton Grower's Conference, New Mexico.
35. 30 Jan 2020. NexGen Cotton Symposium, Pinal County, Arizona.
36. 3-4 Feb 2020. New Mexico Chili Pepper Conference, New Mexico.
37. 5 Feb 2020. Deltapine Seed Meeting, Pinal County, Arizona.
38. 21-22 Feb 2020. New Mexico Organic Farming Conference, New Mexico.
39. 10 Mar 2020. New Mexico Alternative Crops Conference, Portales, New Mexico.

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

Note: Due to COVID-19 restrictions, in-person events have been on hiatus since March 2020.

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.

Biofuel Lessons in Classrooms (SBAR Teacher/Fellow Cohort 2020-2021)

1. Camino Real Middle School, Las Cruces, New Mexico

2. Melrose High School, Melrose, New Mexico
3. Saguaro National Park Environmental Education, Tucson, Arizona
4. Santa Rosa Ranch School, Sells, Arizona
5. Sierra Middle School, Las Cruces, New Mexico
6. Valencia Middle 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. **NOTE:** Due to COVID-19 response, direct youth contact did not occur after March 2020.

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

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

Youth Participation Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
Age Level			
11-13 years	1,242	0	1,242
14-16 years	433	40	473
Gender			
Males	834	24	858
Females	841	16	857
Race/Ethnicity			
Hispanic	893	3	896
Asian	33	0	33
Native American	159	24	183
African American	47	0	47
Anglo/White	538	5	543
Multiracial	6	8	14

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

Note: Due to COVID-19 restrictions, in-person and in-school activities have been on hiatus since March 2020.

PARTICIPANTS AND COLLABORATING ORGANIZATIONS.
September 2017 – December 2020

PARTNER ORGANIZATIONS

Organization Person*	Project Role	Project Component
Bridgestone Americas,		
Von Mark Cruz	Professional	Feedstock Development & Production
David Dierig	Key Collaborator	Feedstock Development & Production
Stefan Dittmar	Professional	Feedstock Development & Production
<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
<i>Jane Turek</i>	<i>Undergrad Student</i>	<i>System Performance & Sustainability</i>
Colorado State University		
<i>Austin Banks</i>	<i>Undergrad Student</i>	<i>System Performance & Sustainability</i>
<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	Characterizations & Co-Products
<i>Meshack Audu</i>	<i>Graduate Student</i> <i>Fellow</i>	<i>Education</i> <i>Characterizations & Co-Products</i>
<i>Valerie Bailey</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Hengameh Bayat	Graduate Student	Characterizations & Co-Products
<i>Sultan Begna</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
<i>Geneva Ben</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
<i>Pratima Bhandari</i>	<i>Graduate Student</i>	<i>System Performance & Sustainability</i>
Catherine E. Brewer	Key Collaborator	Education Characterizations & Co-Products

Nicolas Carrero-Little	Undergrad Student	Characterizations & Co-Products
<i>Pedro Castillo</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Kenneth Cazarez	Undergrad Student	Extension & Outreach
Shivam Chawla	Graduate Student	Feedstock Development & Production
<i>Feng Cheng</i>	<i>Post-doc</i>	<i>Characterizations & Co-Products</i>
Murali Darapuneri	Professional	Extension & Outreach
Mostafa Dehghanizadeh	Graduate Student Fellow	Education Characterizations & Co-Products
Malachai Dehler-Egan	Undergrad Student	Characterizations & Co-Products
<i>Barry Dungan</i>	<i>Professional</i>	<i>Characterizations & Co-Products</i>
Dominic Flores	Undergrad Student	Feedstock Development & Production
<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>Characterizations & Co-Products</i>
Ryan Fullerton	Undergrad Student	Feedstock Development & Production
Claudia Galvan	Professional	Characterizations & Co-Products
<i>Alonso Garcia</i>	<i>Graduate Student</i>	<i>Feedstock Development & Production</i>
<i>Adah Gellis</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
<i>Saba Gill</i>	<i>Graduate Student</i>	<i>Characterizations & Co-Products</i>
<i>Thomas Gloria</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Kulbhushan Grover	Key Collaborator	Extension & Outreach Feedstock Development & Production
<i>Erin Gutierrez</i>	<i>Undergrad Student</i>	<i>Characterizations & Co-Products</i>
Maria Gutierrez	Undergrad Student	Extension & Outreach
Paul H Gutierrez	Key Collaborator	Extension & Outreach System Performance & Sustainability
<i>Befekadu Habteyes</i>	<i>Professional</i>	<i>System Performance & Sustainability</i>
Jose Hackleen	Undergrad Student	Feedstock Development & Production
Mia Herrera	Undergrad Student	Feedstock Development & Production
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John Idowu	Key Collaborator	Extension & Outreach
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<i>Esai Lopez</i>	<i>Undergrad Student</i>	<i>Education</i>
<i>Alberto Lorenzo</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
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<i>Kyle Moore</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
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<i>Camila Prieto</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
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<i>Tarah Schuman</i>	<i>Undergrad Student</i>	<i>Characterizations & Co-Products</i>
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David Struthers	Undergrad Student	Feedstock Development & Production
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<i>Scott Woolf</i>	<i>Undergrad Student</i>	<i>Characterizations & Co-Products</i>
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Torran Anderson	Professional	Education Extension & Outreach
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<i>Armando Barreto</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
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Marielle Cascaes Inacio	Post-doc	Characterizations & Co-Products
<i>Madasu Chandrashekar</i>	<i>Post-doc</i>	<i>Characterizations & Co-Products</i>
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Yongjian Chen	Post-doc	Feedstock Development & Production
<i>German Coronado</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
<i>Kamel Didan</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
Cara Duncan Shopa	Professional	Education Extension & Outreach
Diaa El-Shikha	Post-doc	Feedstock Development & Production
Blase Evancho	Key Collaborator Graduate Student	Extension & Outreach Feedstock Development & Production
Neng Fan	Key Collaborator	System Performance & Sustainability
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<i>Daryan Godfrey</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Leslie Gunatilaka	Key Collaborator	Characterizations & 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>
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<i>Aaron Judkins</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
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<i>Lia Ossanna</i>	<i>Professional</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>
<i>Livvi Pearson</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Alexandra Peck	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>
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<i>Rebecca Sheng</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
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<i>Seth Steichen</i>	<i>Graduate Student Fellow</i>	<i>Education</i>
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<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>
Tony Viola	Undergrad Student	Education
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	Characterizations & Co-Products
Ali Yaylali	Graduate Student Fellow	Education
<i>Stevi Zozaya</i>	<i>Undergrad Student</i>	<i>Extension & Outreach</i>
Weimao Zhong	Post-doc	Characterizations & Co-Products
Daniel Zuniga-Vazquez	Graduate Student	Characterizations & Co-Products System Performance & Sustainability
USDA Agriculture Research Service – US Arid Lands Research Center, Maricopa AZ		
Hussein Abdel-Haleem	Key Collaborator	Feedstock Development & Production

<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>
<i>Tristan Dunton</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
<i>Harmony Glover</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
Doug Hunsaker	Professional	Feedstock Development & Production
<i>Greg Leake</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
Avery Luna	Undergrad Student	Feedstock Development & Production
Lily Luo	Professional	Feedstock Development & Production
Aaron Szczepanek	Professional	Feedstock Development & Production
<i>Brandon Vera</i>	<i>Undergrad Student</i>	<i>Feedstock Development & Production</i>
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>Brandon Bartelmie</i>	<i>Student</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>
<i>Chen Dong</i>	<i>Professional</i>	<i>Feedstock Development & Production</i>
Niu Dong	Professional	Feedstock Development & Production
Trinh Huynh	Professional	Feedstock Development & Production
Kumiko Johnson	Professional	Feedstock Development & Production
Colleen McMahan	Key Collaborator	Feedstock Development & Production
Dante Placido	Post-doc	Feedstock Development & Production
Grisel Ponciano	Professional	Feedstock Development & Production
Mariano Resendiz	Graduate Student	Feedstock Development & Production

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

Total Active Key Collaborators: 24

Total Active Professional Staff: 34

Total Active Postdoctoral Researchers: 7

Total Active Graduate Students: 29

Total Active Undergraduate Students: 28

Total Active Fellows: 9

Total Active /Interns: 0

Total Active Participants: 122

Total Past Participants (no longer active): 111

Total Individuals Involved Since SBAR Inception: 233

COLLABORATIONS AND OTHER CONTACTS

Collaborations:

<p><i>Academic Institutions:</i></p>	<p>CSM (Colorado School of Mines)</p> <ul style="list-style-type: none"> - Dept. of Civil and Environmental Engineering <p>CSU (Colorado State University)</p> <ul style="list-style-type: none"> - Dept. of Mechanical Engineering <p>FSU (Florida State University)</p> <ul style="list-style-type: none"> - National High Magnetic Field Laboratory <p>NMSU (New Mexico State University)</p> <ul style="list-style-type: none"> - Cooperative Extension - Dept. of Agricultural Economics and Agricultural Business - Dept. of Chemical and Materials Engineering - Dept. of Plant and Environmental Sciences <p>UA (University of Arizona)</p> <ul style="list-style-type: none"> - Arizona Institutes for Resilience - Agricultural and Biosystems Engineering - College of Agriculture and Life Sciences - College of Education - College of Engineering - Cooperative Extension - Dept. of Agriculture and Resource Economics - Dept. of Chemical and Environmental Engineering - Dept. of Language, Reading and Culture - Dept. of Soil, Water and Environmental Sciences - Dept. of Systems and Industrial Engineering - Dept. of Teaching and Teacher Education - Institute of Energy Solutions - Natural Products Center - School of Natural Resources and the Environment - School of Plant Sciences <p>UNM (University of New Mexico) – Gallup</p> <ul style="list-style-type: none"> - Dept. of Mathematics, Physical and Natural Science
<p><i>Nonprofits:</i></p>	<p>Environmental Defense Fund, Phoenix AZ</p> <p>Asombro Institute for Science Education, Las Cruces NM</p>
<p><i>Industrial or Commercial Firms:</i></p>	<p>BASF</p> <p>Bridgestone Americas, Inc.</p> <p>Central Arizona Project (CAP)</p> <p>FMC</p>

	<p>Guar Resources Syngenta</p>
<i>Federal Government</i>	<p>Saguaro National Park (West), Tucson AZ - Environmental Education Department</p> <p>USDA – Agricultural Research Service, Western Regional Research Center, Albany CA - Chemistry (Bioproducts) - Plant Genetics</p> <p>USDA – Agricultural Research Service, Grassland Soil and Water Research Laboratory, Temple TX - Crop Modeling</p> <p>USDE – Pacific Northwest National Laboratory, Richland WA</p>
<i>State or Local Governments:</i>	<p>Arizona Department of Agriculture, Environmental Services Division</p>
<i>Tribal Governments:</i>	<p>Ak-Chin Indian Community, Maricopa, Arizona</p> <p>Tohono O’odham Nation, Sells, Arizona</p>
<i>Schools or School Systems:</i>	<p>BASIS Charter Schools, BASIS Tucson North (high school), Tucson, Arizona</p> <p>Flowing Wells Unified District, Walter Douglas Elementary School, Tucson, Arizona</p> <p>Las Cruces Public Schools, Camino Real Middle School, Mesa Middle School, Mesilla Valley Leadership Academy, and Sierra Middle School, Las Cruces, New Mexico</p> <p>Marana Unified School District, Quail Run Elementary School, Marana, Arizona</p> <p>Melrose Municipal Schools, Melrose High School, Melrose, New Mexico</p> <p>Tucson Unified School District, Pueblo High School, and Valencia Middle School, Tucson, Arizona</p> <p>Santa Rosa Ranch School District, Santa Rosa Ranch School, Sells, Arizona</p> <p>Sunnyside Unified School District, Apollo Middle School, Tucson, Arizona</p>

<i>Other Organizations (foreign or domestic):</i>	
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Other Contacts:

<i>Contacts with others within recipient's organization (interdepartmental or interdisciplinary collaborations):</i>	UA (University of Arizona) <ul style="list-style-type: none"> - 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
<i>Contacts with others outside the organization:</i>	Denver Museum of Nature and Science, Denver CO Central Arizona College, Coolidge AZ
<i>Contacts with others outside the United States or with an international organization:</i>	

APPENDICES

APPENDIX 1. EXTENSION & OUTREACH EVENTS

Documents Included

1. **Guayule Field Day (Virtual Field Day)** – Agenda. Event hosted and presented by SBAR, UA Cooperative Extension, and Bridgestone. 15 October 2020.

GUAYULE FIELD DAY

Presented by Bridgestone, UArizona Cooperative Extension and SBAR

Virtual Field Day

Thursday, October 15, 2020

9:00-12:30 PDT

REGISTER HERE: <https://forms.gle/kJ2QoW9Hkjrjv5pcR8>



PROGRAM

- 9:00 - 9:15 Blase Evancho - Welcome & Introduction
- 9:15 - 9:45 Dr. David Dierig - Bridgestone's Vision for Guayule
- 9:45 - 10:15 Dr. Sam Wang - Guayule Agronomic Management
- 10:15 - 10:45 Dr. Bill McCloskey - Controlling Weeds During Guayule Establishment
- BREAK
- 11:00 - 11:30 Dr. Peter Ellsworth - Research Update on Early Season Insect Control
- 11:30 - 12:00 Trent Teegerstrom - Enterprise Budgets and the Whole Farm Analysis Tool
- 12:00 - 12:30 Q&A

Questions? Contact Blase Evancho: 520-705-0871 or bee1@arizona.edu

More about the SBAR Center for Excellence and guayule research at <https://sbar.arizona.edu>



SUSTAINABLE BIOECONOMY
FOR ARID REGIONS



United States
Department of
Agriculture

National Institute
of Food and
Agriculture



Colorado State University



THE UNIVERSITY OF ARIZONA
COLLEGE OF AGRICULTURE & LIFE SCIENCES
Cooperative Extension

BRIDGESTONE



COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

NM STATE
College of
ACES/CES



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